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ORIGINAL ARTICLES.

I.—Note on a nearly complete Skeleton of *Aptornis defossor* (Owen).

By C. W. Andrews, B.Sc., F.G.S., of the British Museum (Natural History).

(PLATE X.)

In a collection of bird-remains sent to Dean Buckland from North Island, New Zealand, in 1842, Professor Owen noticed a tibia which he regarded as belonging to a very small species of Dinornis, to which he gave the name *Dinornis otidiformis*. A few years afterwards further material showed that this bird was not Dinornithine at all, but was probably a gigantic flightless rail, and it was therefore referred to a new genus, *Aptornis*. Subsequently, on the evidence of a nearly perfect skull, considerably larger than that of *A. otidiformis*, a second species, *A. defossor*, was described, and it is to this larger form that the fine skeleton figured on Plate X belongs. The bones from which this specimen was reconstructed were found in 1889, by Mr. W. S. Mitchell, in a chasm in the Limestone at Castle Rocks, Southland, New Zealand; together with them occurred more or less complete skeletons of *Harpagornis* (both species), *Notornis*, a large species of *Fulica*, allied to that recently discovered by Dr. H. O. Forbes in the Chatham Islands, a small *Ocydromus*, *Stringops*, *Anas*, *Apteryx*, and also *Anomalopteryx didina* and *A. didiformis*. A very interesting account of the mode of occurrence of these remains has been given by Mr. A. Hamilton, to whose papers [1] those interested may be referred for further information on this point. The same writer has also given a brief description,[2] with numerous measurements, of the bones of the species with which we are now concerned. It appears that the more or less perfect skeletons of several individuals were found mingled with one another; and, although the greater number of the bones constituting the present specimen no doubt belonged to

[1] "On the Fissures and Caves at the Castle Rocks, Southland; with a Description of the Remains of the Existing and Extinct Birds found in them": Trans. New Zealand Institute, vol. xxv (1892), p. 88. Also, *op. cit.*, "Result of further Exploration of the Bone-fissure at the Castle Rocks": vol. xxvi (1893), p. 226.

[2] "On the Genus *Aptornis*, with more especial reference to *Aptornis defossor* (Owen)": *op. cit.*, vol. xxiv (1891), p. 175.

a single bird, the missing ones have been replaced by portions of the other skeletons.

A figure of the restored skeleton of this species was published by Owen, but it was largely conjectural, and as far as the vertebral column is concerned, is merely a magnified *Ocydromus*, differing in many respects from the present specimen, notably in the larger number of vertebræ bearing free ribs. It is of course possible that some may have been omitted, but examination of the column as a whole does not bear out this supposition, the various processes undergoing quite gradual modification in form and size when followed from one region to another. In the cervical region the most remarkable character is the great size of the anterior vertebræ, resulting from the enormous development of the various ridges and processes. The peculiar long, slender coracoids are anchylosed with the much reduced sternum; by Owen, Fürbringer, and others, these bones were referred to *Cnemiornis*, but their true nature has been pointed out by Forbes and Lydekker. The figure shows the probable position of the scapula in relation to the coracoid, the coraco-scapular angle being very obtuse, as in most flightless birds; the humerus is proportionately small, and its pectoral crest is reduced to a mere tubercle.

The large pelvis and powerful hind-limb indicate a bird well adapted for "cursorial," and probably, as Owen suggested, for "rasorial" habits.

On a future occasion it is proposed to give a detailed account of the more important characters of this skeleton.

II.—On Enclosures of Glass in a Basalt near Bertrich, in the Eifel.

By Mary C. Foley, B.Sc.

During a short holiday spent last summer in the Eifel, I was much struck with the occurrence of an extremely vesicular, dark-green glass in the lava at Bertrich, the most southerly point of the district at which traces of volcanic action are to be met with. It lies in the valley of the Uessbach, a little stream that flows into the Alf, a tributary of the Moselle. In all probability the ground on which Bertrich now stands was at one time covered with lava, and if the course of the Uessbach be followed for about a mile and a half above the town, thick patches of it may be clearly seen on either side of the present bed of the stream, all traces of it ceasing higher up the valley. It is well exposed in a quarry known as the Mühlrech, on the left bank of the Uessbach immediately below the high road to Kenfus, and about a mile above Bertrich. Here the lava exhibits a fine section about 90 feet high, but it is being rapidly cleared away for road metal. The quarry lies immediately at the mouth of a side-valley called the Müllischwiese, which commences near the foot of the Falkenlei, one of the three craters that overshadow Bertrich, and gently slopes down for a distance of about three-quarters of a mile into the valley of the Uessbach. The

lava which can be thus so easily traced down to Bertrich is part of a great stream which in all probability commenced at some point in the Müllischwiese, and followed the course of the Uessbach, filling its channel to a considerable height. On its way it forms the well-known "Cheese Grotto," about half-a-mile above Bertrich. It is difficult to determine the exact spot in the Müllischwiese at which the flow commenced, for the valley is now all under cultivation and much overgrown in places, and no traces of the flow can be seen except at the quarry to which I have referred, which is at the junction of the two valleys. Excavations have now been commenced immediately above the quarry by the side of the high-road; and the lava which is there being exposed is exactly similar to that seen below in the large quarry, only it is not so hard and compact, and presents a somewhat slaggy appearance.

It was in the Mühlrech quarry that I found many specimens of the dark-green glass to which I have alluded. It occurs in irregularly-shaped patches, and apparently forms a thin lining to cavities in the lava. The latter is a hard, dark-coloured rock of basic composition, and consists mainly of crystals of augite and olivine imbedded in a dark-brown, glassy ground-mass, which is rich in magnetite. I have found no traces of felspar, leucite, or nepheline. Zirkel [1] thinks that the last may occasionally be present, although its outlines are indistinct, and also sanidine.

As far as I am aware, but little attention has been drawn to this curious feature of the Bertrich lava. Roth [2] attributes the origin of the green vesicular glass found in the scoriæ and lavas of Bertrich, the Falkenlei, and Hüstchen, another of the three craters to which I have already referred, to the melting down of the augite present in the lavas. "An alteration," he says, "of the olivine is nowhere to be observed, a result of the difficulty with which it fuses." Von Dechen [3] thinks that Roth's explanation is unsatisfactory; for were it correct, the glass would undoubtedly be found in lavas and scoriæ from other parts of the Eifel, since augite occurs so abundantly in them all. "Probably," he adds, "the melted augites would not lie next to the unaltered ones, and, moreover, would not have preserved the granular form of the latter while enclosed in the thick lava, whereas in reality longitudinal sections of lenticular bodies are to be found there." [4]

At first sight the colour and lustre of the glass led me to suppose that it was melted olivine; and no satisfactory proof having

[1] "Basaltgesteine," p. 180. Bonn (1870).

[2] E. Mitscherlich, "Ueber die vulkanischen Erscheinungen in der Eifel und über die Metamorphie der Gesteine durch erhöhte Temperatur": Im Auftrage der Königl. Akademie der Wissenschaften zu Berlin herausgegeben von J. Roth, 1865, p. 29.

[3] "Geognostischer Führer zu der Vulkanreihe der Vorder-Eifel," p. 26. Bonn (1886).

[4] Possibly he refers to the streak-like form sometimes taken by the glass; but his meaning is not clear to me. His words are: "Wahrscheinlich würden die geschmolzenen Augite nicht neben den unveränderten liegen und deren Körnerform in der dichten Lava eingeschlossen bewahrt haben, sich längliche Durchschnitte linsenförmiger Körper darstellen."

apparently been given by Roth as to whether it were really melted augite, I commenced a microscopic examination, which brought to light some curious features. The glass in thin sections is of a pale olive-green colour, containing many delicate colourless trichites, and it gives, as one would expect, total extinction. Its junction with the ground-mass of the rock is very thickly fringed with dense masses of microliths of all sizes, for the most part of prismatic shape, their edges in some cases ragged and incomplete, and most of them colourless, with dark inclusions, probably of iron-oxide. They react very markedly on polarized light, showing brilliant colours with crossed nicols. The shape of the prisms, the total absence of pleochroism, and their high extinction angle (ranging up to 43°), prove that they are some form of augite. Here and there they are arranged in rings, and little nests of them lie dotted about in the slide; the majority, however, seem to cling to the edge of the ground-mass. Lying in the latter and all but touching the glass are crystals of augite and olivine, which do not appear at all altered, but have preserved their usual shape and appearance; while in the glass itself, near the ground-mass, are one or two small crystals of augite which appear to be a good deal altered, the edges being very ragged, with tiny microliths clinging to them and, as it were, eating their way into the crystal. In some places the glass appears slightly stained with the dark-brown colour of the ground-mass, but on the whole the latter is separated from the glass by a distinct border.

Being still unwilling to relinquish my original idea that I was dealing with melted olivine—possibly a lime-bearing variety, which in cooling might have developed partially into some form of augite—I proceeded, at Prof. Bonney's suggestion, to fuse in the oxygen flame pieces of augite and of olivine taken from the rock itself, the fragments being held in each case in platinum forceps.[1] The augite (of the common dark-brown type) fused fairly easily, and turned into a dark glassy-looking bead with a somewhat resinous lustre. This was powdered, mounted, and examined under the microscope. The fused part was then seen to be a pale yellowish-green glass, very similar in colour to that in the Bertrich lava. The olivine, however, did not fuse so easily, although the fragment was held in the flame for about two minutes longer than the augite.[2] It turned into a black bead and adhered very firmly to the forceps; but on mounting the fragments, microscopic examination showed that a mere outer film had been melted, and the particles fused had turned into an extremely black opaque glass, totally unlike that in the Bertrich lava. The bit of olivine which I had tried to fuse was fairly pure, but contained a few granules of iron. A small chip of the rock itself was treated similarly to the olivine and augite, and it was melted down almost immediately into a rich brown glass.

[1] I am greatly indebted to Miss Aston, B.Sc., for assisting me with these experiments, which were carried out in the Chemical Laboratory of University College.

[2] Still, Prof. Daubrée states that he fused olivine without much difficulty; this, however, was done under the influence of prolonged heat in a furnace.—"Géologie expérimentale," vol. ii. Paris (1879), pp. 517-523.

The results afforded by fusion certainly go to prove that Roth was correct in his statement that the Bertrich glass is melted augite and not olivine, although in the hand-specimens appearances are strongly in favour of its being the latter. That the glass owes its origin to any secondary heating, is very improbable; for it is difficult to conceive of any causes in a lava-flow that would bring about a local rise of temperature, without affecting the ground-mass of the rock and the minerals enclosed in it, especially as the rock itself fuses so quickly and thoroughly. Neither do I think that the formation of the glass can be due to the rapid cooling, under little or no pressure, of melted augites, which were carried along on the surface of the lava stream. In that case it would be impossible to explain the occurrence of totally unaltered augites lying side by side with this glass. I found the latter in hard and compact lava, not at all slaggy in appearance, with distinct signs of columnar structure set up in it; hence the cooling down must have taken place slowly. Prof. Bonney has suggested that the pieces of glass are fragments of some deep-seated magma almost agreeing in composition with pyroxene, which, indeed, occurs as a rock.[1] These were carried up to the surface in the liquid lava from some subterranean reservoir, and cooled at first very rapidly and in a different manner to the augites in the current. Partial devitrification may possibly have taken place owing to changes of temperature at some stage before the final solidification of the mass, but I think it is more probable that the enclosed microliths may have formed, owing to local circumstances, when the glass actually became solid. The pieces of augite in the glass with ragged edges and altered appearance were doubtless entangled in it while it was still in a liquid condition. The little rings in the glass formed by the microliths are probably due to the latter collecting round some of the numerous vesicles, for, as I have already stated, the glass is very vesicular. I think it is thus possible to explain the occurrence of unaltered augites and olivines lying immediately next to the glass in the ground-mass of the rock, and the non-intermingling of the latter with the glass.[2] Von Dechen's objection, viz. the non-occurrence of the glass in other Eifel lavas, does not seem to me to carry much weight, as one would not necessarily expect to find fragments of a deep-seated magma (and this one of rather exceptional composition) in every flow. He apparently found melted and unmelted augites lying side by side in the lava. This has not been my experience, but as he concludes his description of the rock by saying that microscopic examination would probably lead to the further clearing up of difficulties,[3] it is reasonable to suppose that he did not carry out such an examination, which would doubtless have considerably influenced his opinion.

I cannot conclude this brief communication without acknowledging my indebtedness to Prof. Bonney for his kindness in examining my hand-specimens and slides, and for his valuable advice.

[1] Viz. pyroxenite and hornblendite.

[2] Miss C. A. Raisin, B.Sc., has kindly shown me a piece of tachylitic glass occurring in a dark leucitic lava of unknown locality.

[3] *Loc. cit.*, p. 26.

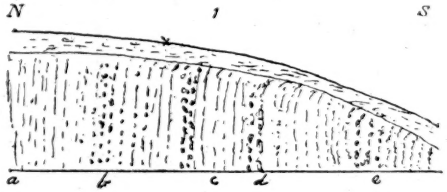
III.—Vertical Tertiaries at Bincombe, Dorset.

By the Rev. O. Fisher, M.A., F.G.S.

I HAVE just read the abstract of Mr. Clement Reid's paper to the Geological Society (April 29, 1896) upon the Eocene deposits of Dorset. Many years ago I paid a good deal of attention to these beds, and have many notes upon what I saw. The section which I now send is reduced from my notebook, a section which in my belief has never been seen by any geologist except myself. It was taken when a large pit was open, and the section clear and unmistakable. I copy the words I wrote on the spot. "December 24, 1855. Examined the large gravel-pit recently opened in the Tertiary Eocene beds at Bincombe. A section is given on the last leaf [of the notebook]. The deep cuttings lately made show the

Sections of Eocene beds at Bincombe, Dorset, exposed in 1855. Depth of section about 24 feet.

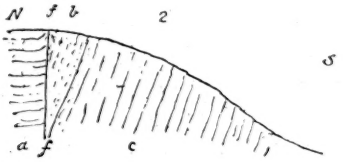
Fig. 1.



(*a*) Sand and coarse pipeclay.
(*b*) Round gravel of flint pebbles, black inside.
(*c*) Sand and clay.
(*d*) Blocks of cherty grey flint, with numerous casts of fossils.
(*e*) Subangular flint gravel, not ochreous, used for road metal.

beds to be vertical, following the dip of the chalk. The beds have much the character of those at Bournemouth, except that they are much coarser. The place of the large flints with fossils is shown in the section.[1] The manner in which the ends of the vertical beds

Fig. 2.



(*a*) Horizontal chalk.
(*f*, *f*) Fault.
(*b*) Eocene beds.
(*c*) Nearly vertical chalk.

[1] These casts were frequently collected by the Rev. W. Barnes, the Dorsetshire Poet. There were formerly some in the Dorchester Museum. Similar casts occur at Haldon Hill, near Exeter, and also in the neighbourhood of Evershot.

are bent over, and dragged down the slope of the hill, is particularly well shown."

Perhaps, if Mr. Strahan had seen this section open as I did, he might not have said in the discussion that "in drawing a section through Bincombe he found there was not room for the whole of the chalk below the Tertiary outlier"—for it is not an "outlier" in the usual sense of the word. The chalk and these Tertiaries are, in fact, both tilted together. The chalk at the mouth of the tunnel, about a quarter of a mile to the west, is distinctly vertical. I watched the construction of the tunnel, and am certain of this. I think, therefore, that the Tertiaries above Bincombe are a V-shaped mass, let in along a fault where nearly vertical beds abut on nearly horizontal chalk, as is the case at Ballard Head; although at that place there are no Tertiaries, only vertical chalk abuts on horizontal chalk. But there are localities in the same run of country where vertical chalk is backed by Tertiaries; for instance, at Arisk Mell, and at West Lulworth. Section No. 2 of Sheet 22 of Horizontal Sections of the Geological Survey shows a small patch of Tertiaries, caught in between the vertical chalk of Bindon Hill and horizontal chalk north of it. At all these places I suspect the structure to be as at Bincombe, and much as is indicated in Diagram No. 2.

If my theory be correct, then the coarse subangular gravel at the south end of the section is the lower, and the sandy pipeclay to the north the higher, part of the series which was exposed.

IV.—Note on some Cretaceous Fossils from the Drift of Moreseat, Aberdeen.

By G. Sharman and E. T. Newton.

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In the year 1856 Mr. J. W. Salter and Mr. W. Ferguson described before the Geological Society (Q.J.G.S., vol. xiii. p. 83, 1857) a series of fossils which had been collected from Drift material at Moreseat and other localities near Aberdeen, and seemed to indicate the occurrence of Cretaceous rocks *in situ* at no great distance from this locality.

These fossils were divided into two sets—a series contained in flint, which was referred to the Chalk, and a series preserved in fine sandstone, which was regarded as Upper Greensand.

The genera and species recognized in the flints doubtless included both Lower and Upper Chalk forms; and those recorded from the sandstone, fairly indicated an Upper Greensand facies; but it will be seen from the additional specimens lately collected, that beds of Lower Greensand age are likewise represented.

Mr. D. J. Mitchell, of Black Hills, Aberdeen, and Mr. A. M. Insch, have recently collected fossils from the same locality of Moreseat, Cruden, Aberdeenshire; and these, through the kind offices of Prof. J. W. Judd, have been forwarded to the Geological Survey for identification, and present points of interest which at the first were not apparent.

The specimens sent, which number between two and three hundred, are all in the condition of internal and external moulds, in a light-coloured, fine-grained sandstone; and although slight differences may be noticed in different pieces of the rock, they are all so similar that one can scarcely question their having been originally derived from the same bed. Notwithstanding this the fossils clearly indicate more than one horizon.

Most of Salter's type specimens are preserved in the Museum of Practical Geology, having been presented by Mr. Ferguson; and the matrix of those referred to the Upper Greensand is like that of the specimens which form the subject of this note.

Several forms, in addition to those mentioned by Salter, have been identified; and as some indicate lower horizons than the Upper Greensand, some remarks upon certain of the species are called for. These specimens being, as above stated, in the condition of moulds, it has been necessary to take impressions of the cavities; and these give the external forms of the shells, some of which are thus reproduced in a beautifully perfect manner; this was especially the case with the *Trochus pulcherrimus* and *Echinocyphus*. At first we were prepared to find these fossils to be of Upper Greensand age, as stated by Salter; and when we became aware that several of the forms were of a Lower Greensand or Speeton Clay type, we consulted with our friend and colleague, Mr. Lamplugh, who for years has been familiar with the Speeton fossils, and he at once recognized in the Ammonites and some other forms a distinctly Speeton facies. We are much indebted to him, not only for valuable suggestions, but also for the opportunity of comparing our specimens with his large series of Speeton fossils.

Cephalopoda.

Ammonitidæ.—Three Ammonites were recognized by Salter, but only one specific name was given in the list, namely, *Ammonites Selliguinus*, Brong.? and this with doubt. We have seen nothing that could be referred to Brongniart's species.

Ammonites (*Olcostephanus*) *Speetonensis*, compressed variety.—The two forms figured by Salter, but not named, we have recognized. One of these (Salter, pl. ii, fig. 10) was said to be allied to *Ammonites Jeannotii* (D'Orb., Terr. Cret., pl. lvi); but we recognize a closer relationship to *Ammonites Speetonensis*, and it seems to us to come nearest to the form called by Pavlow *Olcostephanus* (*Simberskites*) *Payeri* (Bull. Imp. Soc. Moscow, 1891, pl. xviii, fig. 1); but although flatter forms than that figured by Pavlow occur at Speeton, none are so much compressed as some we have from Moreseat; this, however, may be due to pressure in the rock. The obliquity of the ribs varies in different specimens. We regard this Ammonite as a flattened variety of *A. Speetonensis*. The *Olcostephanus Phillipsii* (Neumayer, Palæont., vol. xxvii, pl. xv, fig. 7) from the Hilsbildungen, is another closely allied form.

The second specimen figured by Salter (pl. ii, fig. 9) is related to the flattened variety of *Speetonensis*, and this we have also recognized,

but only by fragments which prevent a definite determination. Our specimens do not allow us to see so near an alliance with *Ammonites Pailletteanus*, as Salter and Baily seemed to recognize (Q.J.G.S., vol. xiii, p. 87).

Ammonites (*Hoplites*) *Mortilleti*, Pictet and De Loriol.[1]—Several fragments, and one or two more perfect specimens, indicating Ammonites of from one to two inches diameter, we refer to this species. At first we thought they were *A. noricus*; but the ribs upon the back do not tend to meet at an angle as they do in that species. The specimens all seem to show that the shell was compressed to about the same extent as, or even more than, in *A. noricus*; that the umbilicus was very open, there being scarcely any overlap of the whorls; the outer ones doing little more than touch the inner ones. Around the umbilicus the ribs are nodular, and upon the sides they quickly divide into two or three ribs which pass to the back with a slight sigmoid curve; the curve is probably more marked in larger shells. On each rib, where it bends over to the back of the Ammonite, there is a small but distinct tubercle. The ribs extend a short way towards the middle of the back, and at right angles to it, but a smooth space is left along the middle line. There is no evidence of the ribs upon the back being angulated as they are in *Ammonites noricus*. This Moreseat Ammonite has some resemblance to *Ammonites splendens*, but in that species the back is more definitely flattened, the tubercles are really swollen terminations of the ribs, and the umbilicus is very small.

There is one specimen in Mr. Lamplugh's collection from the upper part of the *Noricus* beds at Speeton, about one inch in diameter, which we believe to be specifically identical with the form now being considered; and there is a second which M. Pavlow has referred to *A.* (*H.*) *Mortilleti*. It seems very probable that the two Speeton forms are the same species; but the one seen by M. Pavlow, which is nearly $1\frac{1}{2}$ inches in diameter, has the tubercles, upon the outer part of the last whorl, placed at irregular intervals.

Crioceras Duvalii?—Several fragments, some indicating whorls $1\frac{1}{2}$ inches wide, and others much smaller, are doubtless referable to this genus: the large transverse ribs, with several smaller ribs in between them, and the presence on some of the larger ribs of spines, irregularly placed, give to these specimens a strong resemblance to *Crioceras Duvalii*; but the evidence is not sufficient for definite determination.

Belemnites.—Several pieces of *Belemnites* have been detected, but they are too small and fragmentary for determination; one may, perhaps, be *Belemnites minimus*. Mr. Lamplugh, comparing these with Speeton forms, detects nothing that could be referred to *Belemnites lateralis*, but thinks it just possible one or two may be portions of *B. jaculum*.

[1] Paléont. Suisse, Neocomien des Voirons, 1858, p. 21, pl. iv, fig. 2.

GASTEROPODA.

Trochus pulcherrimus, Phil.—Several specimens, about one-third of an inch in length, referable to this species, have been recognized; Phillips' figure of a specimen from the Speeton Clay is scarcely sufficient to allow of identification; but examples in the Museum of Practical Geology and in Mr. Lamplugh's collection seem to be identical with the Moreseat specimens. There is some slight variation to be traced among the specimens from each locality; but all seem to be characterized by two keels, more or less crenulated, one at the lower part and another at the upper part of each whorl, between which there is a broad, concave area, marked by numerous fine, oblique threads, running in the direction of the lines of growth, and crossed by a few longitudinal threads. The flattened base is similarly marked by two sets of lines, which, being much coarser, give a more cancellated appearance to this part of the shell. There is no umbilicus, and the mouth is nearly round.

Trochus, sp.—Another form, about half an inch in length, which we refer to this genus, is likewise represented in the Speeton Clay; its sides are flat, and the sutures are not depressed, so that it forms an almost complete cone with flattened sides. At the top and bottom of each whorl there is a slightly crenulated ridge, and between these there appear to have been fine, oblique lines of growth.

Actæon, sp.—Two or three specimens referable to this genus have been noticed: the body-whorl is inflated and marked by a few (four or five) impressed lines; the spire is little more than half the height of the body-whorl.

Cerithium aculeatum, Forbes MS., var.—There is one mould of a *Cerithium* very well preserved, which agrees so closely with the specimens from Speeton, to which Prof. Forbes attached the above name, that we feel assured it is the same species, or, at most, a variety of it; and we gladly adopt the name, although no description of the species has yet been published. The Moreseat specimen is $\frac{7}{16}$ths of an inch long and $\frac{1}{8}$th of an inch wide at the largest part; and one may count 13 or 14 whorls. Each whorl has a strongly-marked nodular ridge near the top, and another, slightly smaller, at the base; between these are two, sometimes perhaps three, thread-like lines, and there are indications of a fine line at the top and another at the base between the suture and the larger ridges. The base of the last whorl is rounded and marked by four to six longitudinal lines. The whorls are crossed obliquely by strong ribs, eight of which may be seen at one time on the lower whorls. The ribs are large above and rapidly attenuate below, and where they cross the longitudinal lines produce nodular markings.

Compared with the Speeton Clay *C. aculeatum*, it will be noticed that in the latter the ridges and ribs are more sharply cut, and the thread-like lines at the top and base of each whorl are more definite; and, further, each whorl has three longitudinal lines between the two larger ones; also, about nine ribs may be counted on one side of each whorl.

LAMELLIBRANCHIATA.

Astarte (*Venus*) *striato-costata*, Forbes.—There are several small specimens of an *Astarte* with few and strongly-marked ribs, which without doubt are the same as some from the Lower Greensand in the Museum of Practical Geology, and there is no question as to these being the forms called by Forbes *Venus striato-costata*. One of the Moreseat specimens, however, shows a very definite lunule, and the margins of the shell are crenulated; so that its reference to *Astarte* seems to us necessary. The correctness of Forbes' reference of these to *Astarte striato-costata* of D'Orbigny may be open to doubt, but for the present that name is retained.

Trigonia vectiana, Lyc.—Two or three small pieces of a *Trigonia*, which so far as they are preserved agree better with *Trigonia vectiana* than with any other form, are referred to that species.

Goniomya, sp.—One fragment of a *Goniomya* has been detected; but while there is no question as to the genus, it is not sufficient for specific determination; it might be *Goniomya Villercensis*, a doubtful example of which is in the Cunnington Collection in the Museum of Practical Geology.

Cyprina Fergusoni, Salter.—Many fragments appear to us to represent Salter's species, the type of which has been compared; but with them there are portions of another form, having similar thread-like markings, but a different outline, and these we refer to the following genus.

Lucina, sp.—Several fragments, and one or two nearly perfect moulds of the exterior, indicate the genus *Lucina*. The markings on these specimens are fine, concentric thread-lines, so like those of *Cyprina Fergusoni* that it is uncertain to which genus many fragments belong. The more perfect examples, however, have less prominent umbones than *Cyprina Fergusoni*, and they overhang the lunule; the entire shell is nearly orbicular. We have been unable to refer this definitely to any described species; the markings are similar to those of *Lucina Dupiniana* of D'Orbigny (pl. cclxxxi), but the produced anterior extremity of that shell, and its prominent umbones, are unlike ours. There are some specimens from the Upper Greensand, in the Museum of Practical Geology, somewhat resembling these Moreseat specimens, which have been doubtfully referred to *Lucina Dupiniana*.

Cucullæa carinata, Sby.—This is, perhaps, the most abundant fossil among the Moreseat specimens, and occurs both as internal and external casts, the largest being a little more than an inch long; it seems to us to agree with the true *C. carinata*, the strong ribs both at the front and back of the shell being of uniform size and not as described in *Cucullæa securis*, D'Orb., which is one of the forms occurring at Speeton.

Cardium Raulinianum, D'Orb.—Two or three examples of a finely-striated *Cardium*, about half an inch in diameter, are referred to this species.

Arca Raulini?, D'Orb. — One specimen, showing part of both valves, is in all probability this species.

Plicatula placunea, Lamk.—There are many specimens, more or less fragmentary, which are referred to *Plicatula placunea*; they are very strongly marked, and agree closely with examples in the Museum of Practical Geology. The variable nature of this genus may lead to doubt as to the correctness of this determination; but none of the Upper Greensand species are so coarsely marked as these from Moreseat, while those from the Lower Greensand agree precisely.

Lima Dupiniana, D'Orb. — Two specimens from Moreseat agree better with this species than with *Lima semisulcata*; the outline of the shell is less equilateral than in the last-named species, the ribs are sharp and fine, with little or no ornamentation, and the interspaces are wide. Salter gives *Lima semisulcata* in his list, but it is just possible that it may be the same form as the one we now have.

Gervillia solenoides, Defr.—This species is represented by one very perfect specimen, about two inches long, which agrees very closely with specimens from the Gault, and consequently is thus named.

LIST OF FOSSILS (CRETACEOUS) FROM MORESEAT, ABERDEEN,

SHOWING RANGE OF THE SPECIES.

Mitchell Collection.	Insch Collection.	Ferguson Collection.		Lower Greensand, Speeton Clay, etc.	Gault.	Upper Greensand.	Chalk.
			Cœlenterata.				
		F.	Micrabacia coronula, Goldf.	—	—	x	x
			Echinodermata.				
		F.	Ananchytes [Holaster]	—	—	—	—
		F.	Diadema	—	—	—	—
		F.	Discoidea	—	—	—	—
		F.	Galerites [Echinoconus] castanea, Brong. ..	—	—	x	x
M.		F.	Enallaster (Toxaster) Scoticus, Salt. ..	—	—	—	—
M.			Echinocyphus difficilis, Ag.	—	—	x	x
			Annelida.				
	I.		Serpula	—	—	—	—
			Polyzoa.				
	I.		Entalophora?	—	—	—	—
			Brachiopoda.				
		F.	Rhynchonella compressa, Lam. [?=dimidiata]	—	—	x	—
M.	I.		Rhynchonella sulcata, Park.	x	x	x	—
M.	I.		Terebratula	—	—	—	—
M.	I.		Waldheimia hippopus *var.* Tilbyensis, Dav.	x	—	—	—

Mitchell Collection.	Insch Collection.	Ferguson Collection.		Lower Greensand, Speeton Clay, etc.	Gault.	Upper Greensand.	Chalk.
			Lamellibranchiata.				
M.			Arca Raulini ?, D'Orb.	x	?	—	—
M.	I.		Astarte (Venus) striato-costata, Forbes ..	x	—	—	—
M.	I.	F.	Avicula simulata, Baily	—	—	—	—
M.			Crassatella (probably)	—	—	—	—
M.			Cardium Raulinianum, D'Orb.	x	x	—	—
M.			Corbula	—	—	—	—
M.	I.	F.	Cucullæa carinata, Sow.	—	x	x	—
M.	I.	F.	Cyprina Fergusoni, Salt.	—	—	—	—
M.	I.		Exogyra ?	—	—	—	—
M.			Gervillia (near to rostrata ?)	—	—	—	—
M.			,, solenoides, Defr.	x	x	x	—
M.	I.		Goniomya, sp.	—	—	—	—
M.	I.		Inoceramus	—	—	—	—
M.			Lima Dupiniana, D'Orb.	x	—	—	—
		F.	,, semisulcata, Sow.	—	—	x	—
M.	I.		,, (near to abrupta)	—	—	—	—
M.		F.	Limopsis texturata, Salt.	—	—	—	—
M.	I.		Lucina ?, sp.	—	—	—	—
M.			Nucula	—	—	—	—
M.			Ostrea ?	—	—	—	—
	I.		Panopœa	—	—	—	—
M.			Pecten orbicularis, Sow.	x	x	x	x
		F.	,, (probably the P. corneus of Nils., not of Sow.)	—	—	—	—
		F.	Pectunculus umbonatus, Sow.	—	—	x	—
M.		F.	Pinna tetragona, Sow.	x	x	x	—
M.	I.		Plicatula placunea, Lam.	x	x	—	—
M.	I.		Spondylus	—	—	—	—
M.	I.		Trigonia vectiana, Lyc.	x	—	—	—
			Gasteropoda.				
M.			Actæon	—	—	—	—
	I.		Cerithium aculeatum, Forbes MS.	x	—	—	—
	I.		Phasianella (near to ervyna, D'Orb.) ..	—	—	—	—
M.	I.		Trochus pulcherrimus, Phil.	x	—	—	—
		F.	,, (small elongated form) [?=pulcherrimus]	—	—	—	—
M.	I.		Trochus (conical species)	—	—	—	—
M		F.	Dentalium cœlatum, Baily	—	—	—	—
			Cephalopoda.				
M.	I.		Ammonites Mortilleti, P. and De Lor. ..	x	—	—	—
M.	I.		,, Speetonensis (*cf.* Payeri, Pav.)	x	—	—	—
		F.	,, Selliguinus, Brong. ?	—	—	—	—
	I.		Belemnites	—	—	—	—
M.	I.		Crioceras Duvalii ?, Lev.	x	—	—	—

Brachiopoda.

Rhynchonella sulcata, Park. — Several fragments of a coarsely-marked shell are believed, with little doubt, to represent this species.

Waldheimia hippopus var. *Tilbyensis*, Dav.—Two moulds of this brachiopod have yielded casts, so exactly resembling examples of this variety in the Museum of Practical Geology, that we have no doubt as to the determination.

ECHINODERMATA.

Enallaster (*Toxaster*) *Scoticus*, Salt.—Several more or less fragmentary specimens doubtless belong to the species thus named by Salter and Baily, which seems to be nearly allied to *E. granosus*, from the Neocomian; but as the Moreseat specimens are too imperfect to speak of positively, we prefer to allow the above name to remain.

Echinocyphus difficilis, Ag.—One very perfect example of this form we have detected in these collections, and its agreement with Upper Greensand specimens is so close, that it must be referred to this species. This specimen supplies the most definite evidence we have in the Moreseat collections of a form only recognized hitherto in the Upper Greensand, or newer beds.

A study of the list on pp. 252–3, with the distribution of the species, will suffice to show that the Moreseat fossils represent more than one of the horizons recognized in the southern parts of Great Britain; for while the *Echinocyphus difficilis*, *Micrabacia coronula*, *Galerites castanea*, and *Pectunculus umbonatus* indicate an Upper Greensand fauna, the *Ammonites*, *Crioceras*, *Trochus pulcherrimus*, *Astarte striatocostata*, *Trigonia vectiana*, *Cardium Raulinianum*, *Arca Raulini* ?, *Plicatula placunea*, and *Lima Dupiniana* point even more strongly to a Lower Greensand age. As already pointed out, the rock in which these fossils occur is so similar throughout—although some pieces, it is true, are a little harder than others, and some are stained with iron—that it is difficult to understand their being from different beds; it would seem, therefore, that the faunas which in the south mark the distinct horizons of Lower Greensand, Gault, and Upper Greensand, are, here in Aberdeenshire, included in one bed of nearly uniform character throughout. However that may eventually prove to be, it is clear that these Drift specimens have been derived from beds where a large part of the Cretaceous series of strata occurs; not only Upper and Lower Chalk, and Upper Greensand, as pointed out by Salter, but also beds of Lower Greensand or Speeton Clay age; but nothing so old as the *Belemnites lateralis* beds of Speeton has been detected.

What relations these beds may have to the Lower Cretaceous of Sweden, or to the Neocomians of Heligoland and North Germany, which are now occupying the attention of Dr. Dames and Prof. von Könen, it will be of interest to know; but this must await future investigation.

Note.—Salter's list of "Fossils found in Chalk-flints from Aberdeenshire" (Quart. Journ. Geol. Soc., vol. xiii, p. 84) includes some from Moreseat.

V.—On Zonal Divisions of the Carboniferous System.

By Wheelton Hind, M.D., B.Sc.Lond., F.R.C.S., F.G.S.

THE question of the zonal division of the Carboniferous system has been raised during the last twelve months, and certain fossils have already been mentioned as typical of a certain succession in a certain district or traverse of rocks. Having studied the Carboniferous system in most of the districts of Great Britain and Ireland where the beds are exposed, and chiefly from a palæontological point of view, I beg to offer for discussion a few of the facts of biological distribution which have come to my knowledge.

There exists, however, a great initial difficulty, one, indeed, which can be gradually overcome, and this is the involved and uncertain state of the nomenclature of Carboniferous Palæontology at the present time. True, that our knowledge of the Brachiopoda of this period is, through the labours of Davidson, well advanced, and that there is some degree of accuracy in the nomenclature of this group, and its synonymy has been well worked out; but if the other groups are in the almost hopeless muddle which I find to be the case with the Carboniferous Lamellibranchiata, I shall be not far short of the truth if I say that at the present time no reliance whatever can be placed on the species and genera, so glibly catalogued in the majority of the works on the Carboniferous system, as being present in, or characteristic of, certain strata.

Some time ago Mr. Morton attempted to define zones in the Carboniferous Limestone beds of North Wales. He did, indeed, succeed in establishing a certain definite sequence in the rocks, but biologically he is able to establish no zones or horizons typified by certain organisms which could be traced across country and recognized as one in different localities.

Before discussing the brief details of zonal distribution given by Messrs. Garwood and Marr,[1] it will be well to ask what is meant by *zonal succession*? I take it, that the idea in seeking for zones of rock, which can be identified by the restricted presence of certain forms of life in definitely marked horizons, is to establish a biological classification of strata. The presence of certain fossils in any given bed is not a simple matter, and is the result of many factors.

A classification of a series of rocks by the horizontal distribution of its fossils, may be always feasible locally, but such a classification is of little real value unless it can be shown to be constant over large areas. As a matter of fact, the distribution of marine organisms is dependent to a very large extent on the depth of water, and zones of life are those of isobathymetrical distribution. In order that the same fossils should be found at certain horizons over a large area, it would have been necessary that the sea-floor on

[1] Geol. Mag., Dec. IV, Vol. II, 1895, pp. 474, 550–2.

which the deposit accumulated was practically level over the same extent.

As a rule, fossils are not equally distributed through Carboniferous strata. Many feet of limestone beds contain nothing beyond microscopic forms of life, but every here and there the beds are crammed with fossil remains, generally speaking, not in the condition in which they lived, but Bivalves and Brachiopods often have their valves separated and are filled with other shells, and many forms which probably did not exist at the same depth are found together though the shells are not rolled.

The value of life zones can be well understood in a series of strata which was deposited without intermission on a floor which was sinking at a uniform rate, without oscillations of level; but even in such a case the beds deposited on the same line of accumulation, near the shore and out at sea, would contain a very different fauna. I shall show later on that such a condition of deposit was anything but characteristic of Carboniferous times.

While, therefore, *life zones* are not altogether to be relied upon in the identification of strata in widely separated areas, neither can they be regarded with any degree of absolute accuracy as indices of the contemporaneity of an extensive horizontal deposit, though similar faunas indicate similar conditions of deposit. Every ocean connotes a shore, and it is therefore obvious that deep-sea life is contemporaneous with littoral and terrestrial forms, and that in a slowly-sinking area, littoral, terrestrial (fluviatile), and pelagic forms would be entombed along the same line of sedimentary deposit, at any rate at right angles to the retreating shore-line, though narrow belts parallel to that line might be characterized by the presence of the same fauna at definite horizons.

If deposition were going on in a rising area the shore-line would gradually advance, and littoral deposits would be formed above the pelagic; but if, on the other hand, the area were gradually sinking, the marine sediments would be superimposed upon the littoral, and thus contemporaneous faunas would become successive.

The greater part of the Carboniferous areas of Great Britain consists of recurring series of sandstones, clays, coals, and limestones, indicating clearly a repeated oscillation of level, with intervening periods of rest, during which the terrestrial conditions necessary for the growth of the coal flora obtained. Such a series of oscillations could only result in repetitions of the faunas typical of terrestrial, littoral, and marine conditions at different horizons in the same vertical series. A good example of this state of things is to be found in the beds of the Calciferous Sandstone series of the Fifeshire coast. This series has been splendidly worked out by Mr. James Kirkby (Quart. Journ. Geol. Soc., vol. xxxvi, 1880, p. 559). Here, in 3,800 feet of strata, several marine bands occur separated by various depths of intervening beds, and containing a large and varied fauna of typical marine facies. True, that the fauna in each of these marine beds is not absolutely identical; but many of the same species recur in several of them. The intervening beds are

sandstones, shales, and indurated clays, with thin beds of coal and many plant-remains. Such a succession points to complete changes in the conditions of deposition; and the beds of coal afford evidence of a suspension of the deposition, and point even to terrestrial conditions.

It would be inadmissible to suppose that the fauna of a marine bed died out when its environment no longer was suitable to its needs, owing to bathymetric change, and that its reappearance at a higher horizon was due to a redevelopment from primordial forms; because it is not probable that many forms would be again evolved on precisely the same lines.

The presence of a fauna at several horizons, with the complete absence of the same forms of life in the intervening beds, points to the continued survival of that fauna in some outside area during the whole of the time that the series of beds containing it were laid down, whence it could migrate in any direction in which the environment became suitable. The change of conditions from marine to littoral and littoral to terrestrial, and *vice versa*, must have been very gradual, giving time to the faunas to retreat and invade fresh localities, and allowing them to remain in an environment suitable for their survival. How long some species did survive, in some outside area, in Carboniferous times, may be judged from the reappearance of the typical Lower Carboniferous species *Productus semistriatus* and *Streptorhynchus crenestria*, amongst others, in the Coal-measures of North Staffordshire. These species are, of course, common enough in the Carboniferous Limestone of the district; but they recur only at one single horizon in the Yoredale series, and once in the Coal-measures. This fact affords undoubted evidence that, at some area, even towards the close of the Carboniferous period, a marine fauna was in existence. This fact at once raises the question as to whether the Carboniferous rocks of the world are contemporaneous. It is quite possible that a slow wave of depression, with occasional shorter waves of return, passed gradually over the surface of the world, that faunas migrated with these waves, and that deposits characterized by similar faunas in the different parts of the earth were anything but contemporaneous. But to follow this question would lead me too far astray for the limits of this paper; still, if American palæontologists are correct in recognizing very few of their fossils as belonging to European species, though generically the faunas are almost identical, such an interval of time may have been the main cause in the gradual change of specific form by the accumulated variations of successive generations.

The beds of the Carboniferous deposits are, as a rule, characterized by repeated alternations and recurrences of similar lithological strata, with recurrences, after great intervals, of similar floras and faunas; and it appears to me that such a series of strata is not as likely to be differentiated by well-marked and isolated zones of life as might obtain in a series of rocks formed by a steady deposit, continued for a long time. In the British Isles it is only in Central England, North and South Wales, Somersetshire, and parts of Ireland

that any Carboniferous rocks exhibit such a persistence of conditions of deposit as the Carboniferous Limestone of Derbyshire; for the majority of the Carboniferous beds north of the Midlands, and in Scotland, exhibit, rather, characters indicative of successive changes. If the thick deposits of Carboniferous Limestone typical of North Staffordshire, Derbyshire, and South Yorkshire be traced north, it appears in the north of Yorkshire to be broken up into different, well-recognized beds, separated by beds of shale of varying thickness, the latter thinning out towards the south. The upper beds (Yoredale) in this district (Ingleborough) contain several beds of limestone, separated by shales, which do not occur in the same series further south. Moreover, many fossils are common to these limestones, and to the "Massif" further south.

Viewing the Carboniferous rocks of Great Britain as a whole, nothing is clearer than the fact that they do not for the most part fall in with the fourfold classification—

Coal-measures,
Millstone Grit,
Yoredale Beds,
Carboniferous Limestone—

of the textbooks. Such a classification will only be found suitable in the field in the North Midlands, and I believe that a twofold division as is made in North America would better represent the British Carboniferous strata.

Upper Carboniferous or Anthraxiferous division		Coal-measures. Millstone Grit series.		
Lower Carboniferous or Calcareous division	England...	Yoredale series. Carboniferous series.	Scotland...	Carboniferous Limestone series. Calcareous Sandstone series.

In this scheme it is not intended for a moment to make out that the two divisions of the Lower Carboniferous in England are the *equivalents* of those in Scotland, or to use the word *equivalent* in any other sense than that in Scotland certain beds are at the base of the series, whilst in England others are in this position. It would appear that in Scotland, Ireland, and the South of England, the Carboniferous period came in gradually, without any very marked change from pre-existing conditions, so much so that there has been much discussion as to the precise position where the line between Carboniferous and Upper Devonian beds should be drawn.

In Yorkshire, where alone in the Midlands the base of the Carboniferous Limestone is exposed, there are only a few feet of impersistent calcareous conglomerate between it and unconformable Silurian rocks. In this area marine conditions seem to have commenced suddenly, and the period of marine encroachment which would have given rise to littoral sediments, to have been of too short a duration to give rise to any deposit.

The majority of the limestone deposits of Carboniferous age are

of marine origin; and a calcareous deposit differs essentially from those of sandstone and clays, in being to no great extent due to terrestrial denudation, and therefore, it may be presumed, that Carboniferous Limestone was laid down in a sea into which the muds and sands brought down by river action were not, or were prevented from being, deposited.

The Carboniferous series of Northumberland and Scotland are essentially characteristic of those deposited near a shore which occasionally became land, and occasionally was depressed deep enough to allow limestones to accumulate on its floor. The land which was the source of the muds and sandstones was probably of no great elevation, and consequently river action was not strong enough to carry the sediments far out to sea. As conditions changed the sea became shallower, and consequently the shore-line retreated south, with occasional intervals and retrogressions; so that in the north, marine, littoral, and terrestrial deposits are found superimposed in varying and recurring sequence, with the faunas peculiar to each also recurring at several horizons in a vertical deposit. Further south, however, constant marine conditions obtained at first for a long time. Deposition of sediment, however, seems to have been in the long run always in excess of the depression, for even in those areas where marine deposits are most constant there is distinct evidence that the sea was gradually becoming shallower, for we find the massive limestones gradually replaced by shale containing thin limestones, and these in turn covered by shales, and sandstones, and clays, during the deposit of which those terrestrial conditions obtained necessary for the growth of such a flora as was to result in the many beds of coal.

We may take it, therefore, that marine and terrestrial conditions existed contemporaneously during the whole of the Carboniferous epoch in Great Britain, and that there was a constant migration of species backwards and forwards, according as conditions slowly changed, and that many forms of life existed in areas where a steady uniformity of environment obtained throughout the whole of that period. Under such conditions zones of biological succession would be of little value as a means for the correlation of rocks over any great areas, with the possible exception of limited belts along the line of strike which would be the equivalents of isobathymetrical zones.

The few fossils quoted as characteristic of a certain succession of the North of England, by Messrs. Garwood and Marr, however indicative they may be of the sequence in a certain locality, seem to me to be singularly unfortunately chosen with regard to the British Carboniferous beds as a whole. The sequence given is—

Beds with *Productus* cf. *Edelburgensis*	Yoredale series.
,, *P. latissimus*	
,, *P. giganteus*	Mountain Limestone series.
,, *Chonetes papilionacea*	
,, *Chætetes septosus*	
,, *Spirifer octoplicata*	

Productus Edelburgensis, Phillips, was regarded by Davidson as a variety of "*P. giganteus* in which the valves are more coarsely striated with interspaces of almost equal or greater width." Phillips gives his localities as Addleburg, Bolland, Fountains Fell, but *P. giganteus* he states is from Aldstone Moor and Hawes. I have found the latter abundantly in beds of Yoredale series in Teesdale. Of course Davidson may have been in error in supposing that *P. Edelburgensis* and *P. giganteus* were the same species, but it would be advisable to prove conclusively that such was the case before the two forms are declared to be typical of different horizons.

In North Staffordshire *P. latissimus* and *P. giganteus* occur together in Carboniferous Limestone at Narrowdale, and in Derbyshire at Park Hill, near Longnor. In Cheshire, at the Astbury limestone quarry, and in the last two localities, *Chonetes papilionacea* also occurs. So that in these localities, at any rate, these three forms cannot be said to be characteristic of different horizons. In these localities *P. latissimus* and *P. giganteus* are very abundant indeed, with a very rich fauna of characteristic Lower Carboniferous facies.

P. giganteus also occurs abundantly in the Redesdale Limestone, Northumberland, a bed which is recognized as the base of the Upper Limestone series in that county, and supposed to correspond to the Yoredale series of Yorkshire. Both *Productus giganteus* and *P. latissimus* are quoted by Lebour ("Geology of Northumberland," p. 116) as occurring together in the Great and Four-fathom Limestones of Lowick, which occur above the Redesdale Limestone and high above the Melmerby Scar Limestone. *P. giganteus* also occurs in the Pipecross Limestone in the Carbonaceous or Lower Limestone series of Northumberland.

In the lists of fossils, arranged stratigraphically, contained in the Memoirs of the Geological Survey, Scotland, explanations of Sheets 23 and 31, *Productus latissimus* and *P. giganteus* are shown to occur together at many horizons, and to have exactly the same vertical range. In the palæontological notes to the memoir of the Irish Survey, "The Geology of the Country round Dublin," *P. giganteus* is stated to occur in three different beds with *Chonetes papilionacea*.

Chonetes papilionacea occurs abundantly in the limestone of Cauldon Low, North Staffordshire, one of the highest beds of the deposit, and probably a much higher horizon than the beds of Waterhouses and Narrowdale, where *P. giganteus* and *P. latissimus* occur. Neither *Chætetes septosus*, as far as my experience goes, nor any other coral occurs at Cauldon Low, which is characterized by abundance of the rare *P. humerosus*, and the stone itself has peculiar and distinctive lithological characters. Davidson quotes *Chonetes papilionacea* from Otterburn, but I can find no authenticated occurrence of this species in Northumberland.

Under such circumstances, therefore, the value of the fossils mentioned as distinctive of zonal succession can hardly be sustained, as the majority of them occur at more than one horizon, and are found in other localities not by any means in the vertical

sequence given. Like many other Carboniferous fossils, they reappear at higher horizons after long intervals, and I have never been able to make out to my own satisfaction any life zones in Carboniferous rocks. What I have observed over and over again is, that a return of similar condition of deposit is accompanied by a return of similar faunas. At the same time, if I could be of any use to other observers in identifying the Lamellibranchiata and Brachiopoda, I should be only too glad to help in any work having for its object the better knowledge of the Carboniferous rocks.

VI.—The Fossils of the Warminster Greensand.[1]

By A. J. Jukes-Browne, B.A., F.G.S.

THE fossils of the Upper Greensand of Warminster have long been known to collectors and geologists on account of their number, variety, and excellent state of preservation; but little information has ever been published regarding the beds which yield them. Collections of the fossils are to be seen in most of the museums of the country, and the fauna represented by these collections has often been regarded as the typical fauna of the English Upper Greensand. This, however, is a mistake, for where fully developed, as in Wiltshire, the Upper Greensand includes two faunas which differ considerably from one another—(1) that of the malmstone and micaceous sand (Devizes Beds), (2) that of the greensands and chert beds (Warminster Beds). The complete succession of the Gault and Greensand Beds near Warminster is as follows:—

6. Light greensand 5. Chert beds 4. Greensand and sandstone	}	Warminster beds.
3. Green and yellow micaceous sands 2. Malmstone	}	Devizes beds.
1. Micaceous clays = Lower Gault.		

When examining the district in 1889 for the Geological Survey, I made every endeavour to ascertain the exact locality or localities from which the so-called Warminster fossils came. I found that most of the fossils which had found their way into museums had been supplied by a man named Baker, who lived at Warminster, and collected them for sale. It was also known that he obtained most of them from a field near Shute or Chute Farm, which is situate about three miles on a straight line south-west of Warminster.

On going to this place I was shown the field in question and a depression which had been a sand-pit. The men employed on the farm informed me that Baker often visited this pit, but that many fossils could be picked up on the surface of the field after it had been ploughed. I had a trench dug down the slope of the old shallow pit, and this proved the existence of about two feet of hard glauconitic and gritty chalk with phosphatic nodules, passing down into softer sandy marl with a few such nodules, and below this a loose greensand of finer grain containing many of the characteristic Warminster fossils.

[1] Published by permission of the Director-General of the Geological Surveys.

It was evident, therefore, that when this pit was worked it exposed a soft fossiliferous greensand overlain by sandy "Chloritic Marl," which is also generally a bed rich in fossils; consequently it is highly probable that the collections made by Baker included all the fossils he could get from both horizons, and from the surface of the surrounding field.

At Rye Hill Farm (Ray Hill on the old Ordnance Map), half a mile south-east of Shute Farm, there are some small pits still open, which show the junction of Chalk and Greensand very clearly, a light-green fossiliferous sand passing up into greenish sandy marl with a few scattered phosphatic nodules, and further up the lane harder "Chloritic Marl" with more phosphates can be found. The chert beds crop out in the lane to the eastward, and the total thickness of the soft greensand cannot be more than ten feet.

The fossils in this sand are chiefly the small Echinoderms and Brachiopods, which are such well known "Warminster fossils." Small lumps of pale-yellow calcareous material also occur in the sand, and some of these are casts of *Ammonites varians* and *Am. curvatus*, which do not occur in any other state of preservation, and are easily distinguished from the casts in brown phosphate which are so common in the overlying Chloritic Marl.

This sand and the Chloritic Marl are not, however, the only sources whence Baker may have got his fossils. He had no knowledge of geology, and would naturally mix together all fossils which he obtained from greensands and sandstones near Warminster. The chert beds, which consist of greenish-grey sands with lenticular layers of chert and cherty stone, are dug for road-metal at Longbridge Deverill, Sutton Veny, Boreham, and Warminster. These beds yield siliceous sponges, some large Echinoderms, *Neithea quadricostata*, *Pecten asper*, and *P. orbicularis*. Still lower are coarse glauconitic sands with a layer of greenish calcareous sandstone, which is the home of four species of *Pecten*—*P. asper*, *P. orbicularis*, *P. Galliennei*, and *P.* (*Janira*) *quadricostata*. These beds are well exposed at Longbridge Deverill, and were doubtless laid under contribution by Baker in making up his collections, for I have detected specimens with this matrix in several museums.

The several beds of greensand above mentioned exhibit differences which enable one who is familiar with them to distinguish land specimens from one another, and the fossils of each can also be separated when sufficient matrix is attached.

Thus the matrix of the chert beds is a pale whitish-grey silty sand, fine-grained and powdery, with very small grains of glauconite; it is often cemented by silica into a hard siliceous stone. The stone-bed below is a rather coarse sandstone, decidedly green from the abundance of glauconite, and cemented by calcite.

The Rye Hill Sand is also rather coarse, with large grains of quartz but with less glauconite, so that in colour it is pale greenish-grey. The sand grains often cling closely to the fossils, and appear to be glued to them by a thin coating of silica.

None of these sands contain mica, so that any fossils imbedded in

a micaceous sand or sandstone may be at once rejected, as they must have come from the lower beds of the greensand, which are so fossiliferous near Devizes.

The fact already mentioned that none of these beds contain phosphatic nodules is of the greatest importance, because it follows that all fossils in brown phosphate should be excluded from the fauna of the Warminster Greensand. Hitherto, nearly every collection has included some of these phosphatized fossils, which are principally casts; but as they have all come from the Chloritic Marl which overlies the Rye Hill Sand, they ought not to be left among the fossils of the Warminster Greensand.

Fossils were collected from the Rye Hill Sand, from the chert beds, and from the sands below, both by myself and by Mr. Rhodes, the fossil-collector of the Geological Survey, and the results are embodied in the following lists. From our observations it would seem that most of the so-called Warminster fossils come from the Rye Hill Sand, but that the large *Janira quadricostata*, most of the larger Echinoderms, and all the large sponges, belong to the chert beds, and, with the exception of *Cardiaster fossarius*, do not range in the upper sands. *Pecten asper* ranges throughout from the basal glauconitic sandstone to the top of the formation and into the Chloritic Marl above.

With regard to the sponges, Dr. Hinde has called my attention to a manuscript written by Miss E. Benett in 1816, and preserved in the library of the Geological Society, entitled "Sketches of Fossil Alcyonaria from the Greensand Formation at Warminster Common and in the immediate vicinity of Warminster." I am indebted to Dr. Hinde for the following extracts from this MS. Miss Benett says:—

"The valley on Warminster Common where these Alcyonaria are found is a poor thin peat covered with furze and heather. The quarries, if so they can be called, for they seldom exceed two feet deep, are on the sides of the hills, as I am informed that the stone on the tops of the hills is too flinty for the purposes for which it is required, and these flinty stones, as far as I have examined them, do not contain any organic remains. The local name of the stone is Burrs; they are used for building and for scythe-stones: these Burrs lie close to the surface in a fine yellow sand, immediately above the greensand, and the nodules containing the Alcyonaria are rather plentiful.

"At Whitburn, near Clay Hill, in the same neighbourhood, the greensand comes to the surface, and these fossils lie in it in the same situation. At Boreham, on the east side of Warminster, the grey sand is uppermost, and there we also found the same sort of fossils, but they are rare; it therefore appears to me that they belong to the top of the sand formation without regard to the sort of sand."

From this it is clear that the sponges were chiefly found to the west of Warminster, and when there in 1889 I found a small quarry open at Bugley in the burr-stone beds described by Miss Benett. It is a fact that on this side of Warminster there is less chalcedonic

chert, and that there are layers and lumps of light-grey siliceous stone and others of calcareous stone in chert beds. The yellow sand mentioned by her is, of course, merely oxidized greensand, and the flinty stones on the hills are flinty cherts accumulated there as insoluble remnants by the gradual detrition and destruction of the chert beds.

I propose first to give a list of the fossils which have been found in the chert beds and in the greensands which underlie them. Those marked S are species which have actually been found *in situ* by Mr. Rhodes or by myself, while those marked M are in other collections, but are believed to have come from the chert beds. For the list of sponges I am indebted to Dr. Hinde.

LIST I.

	Chert Beds.	Lower Sands.
Fishes.		
Oxyrhina Mantelli, Ag.	S	S
Odontaspis	—	S
Pycnodus	—	S
Cephalopoda.		
Ammonites, sp.	—	S
Belemnites, sp.	S	S
Lamellibranchiata.		
Avicula gryphæoides, Sow.	S	S
,, sp.	—	S
Exogyra conica, Sow.	S	S
Inoceramus, sp.	—	S
Lima semisulcata, Sow.	S	S
Lucina, sp.	S	—
Ostrea vesiculosa, Sow.	S	S
Pecten asper, Lam.	S	S
,, Galliennei, D'Orb.	S	S
,, orbicularis, Sow.	S	S
,, (Janira) quadricostata, Sow.	S	S
,, ,, quinquecostata, Sow.	S	S
Polyzoa.		
Entalophora, sp.	—	S
Annelida.		
Ditrupa, sp.	S	S
Serpula antiquata, Sow.	S	S
Vermicularia concava, Sow.	?	S
,, umbonata (?), Sow.	S	S
Echinodermata.		
Cardiaster fossarius, Benett	S	S
,, Perezii, Sism. (Brit. Mus.)	M	—
Discoidea subucula, Klein	S	S
Echinospatagus Collegnii, Sism. (Brit. Mus.)	M	—
Epiaster Lorioli, Wright	M	—
,, polygonus, D'Orb. (Bristol Mus.)	M	—
Holaster lævis (?), Deluc	S	—
,, trecensis (?), Leym.	S	S
Pseudodiadema variolare (?), Brong.	S	—
Salenia, sp.	S	—

	Chert Beds.	Lower Sands.
Siliceous Sponges.		
Carterella cylindrica, Zitt.	M	—
Chenendopora Michelini. Hinde	M	—
Doryderma Benettiæ, Hinde	M	—
,, dichotomum, Benett	M	—
Hallirhoa agariciformis, Benett	M	—
,, costata, Lam.	M	—
,, ,, *var.* brevicostata, Mich.	M	—
,, ,, *var.* elongata, Hinde	M	—
Holodictyon capitatum, Hinde	M	—
Jerea Websteri, Sow.	M	—
,, reticulata, Hinde	M	—
Jereica cylindrica, Hinde	M	—
Kalpinella pateriformis, Hinde	M	—
,, rugosa, Hinde	M	—
Nematinion calyculussa, Hinde	M	—
Pachypoterion compactum, Hinde	M	—
,, robustum, Hinde	M	—
Polyjerea arbuscula, Hinde	M	—
,, lobata, Hinde	M	—
Sclerokalia Cunningtoni, Hinde	M	—
Siphonia tulipa, Zitt.	M	—
Rhopalospongia gregaria, Benett	M	—
,, obliqua, Hinde	M	—
Trachysycon nodosum, Hinde	M	—
Calcareous Sponges.		
Corynella rugosa, Hinde	M	—
,, socialis, Hinde	M	—
Elasmostoma consobrinum, D'Orb.	M	—
,, Normannianum, D'Orb.	M	—
Peronidella furcata, Goldf.	M	—
Pachytilodia infundibuliformis, D'Orb.	M	—
Pharetrospongia Strahani, Sollas	M	—
Hydrozoa.		
Porosphæa urceolata, Phil.	—	s
,, sp.	s	—

It will be noticed that the list of Mollusca is not a long one, and that there is a remarkable absence of Brachiopoda. Echinoderms, again, are not numerous either in species or individuals, and as regards two of the species, *Cardiaster Perezii* and *Echinospatagus Collegnii*, it is very doubtful whether they came from this part of the Greensand: even if they really came from the neighbourhood of Warminster, it is more probable that they were obtained from the yellow sands above the Malmstone which belong to the zone of *Ammonites rostratus.*

Pecten asper is a common fossil in these beds, and so far as this district is concerned they might naturally be grouped as the zone of *P. asper.*

We now come to the fauna of the uppermost bed of greensand which overlies the chert beds, and which is specially fossiliferous on the farms of Chute and Rye Hill. It is from these localities that

most of the so-called Warminster fossils have come, and the list which follows is believed to be a complete catalogue of the fauna of this Rye Hill Sand.

From it have been excluded all phosphatized fossils and all specimens which could be recognized by the matrix as having come from the chert beds below, or from the still lower beds of green sand, yellow sand, and buff micaceous sandstone which occur near Warminster, Westbury, and Devizes. There are, however, still some specimens about the exact *gisement* of which I feel doubtful, and it is possible that a few species have been admitted into this list which have not really come from the particular bed of Greensand in question. If, therefore, it is not a perfectly accurate list, it will err rather in comprehending too many than too few.

I have done all in my power, however, to make it as accurate as possible, and have to thank many friends and correspondents for assisting me in the matter. Messrs. G. Sharman and E. T. Newton have kindly looked at all the fossils labelled "Warminster Greensand" in the cases of the Museum in Jermyn Street, with the result that many were found to be phosphatic casts, and have consequently been excluded from the present list.

For the list of species entered under the second column (British Museum) I am indebted to Dr. W. F. Hume, F.G S., who made a careful examination of the specimens in order to distinguish the true Warminster fossils from such as seemed to have come from other horizons.

The fossils in the Devizes Museum were examined and named by myself in 1888, to the best of my ability at that time. The list of those in the Woodwardian Museum, Cambridge, was made by Mr. H. Woods, F.G.S., but some specimens about which doubt existed were, with the permission of Prof. Hughes, sent to me for examination. In the same way I have to thank the Rev. H. H. Winwood for allowing me to see most of those in the collection at Bath.

The list of Polyzoa is taken from the "Catalogue of the Cretaceous Fossils in the Museum of Practical Geology" (1878); there is also a collection of them in the British Museum, but they are being revised by Dr. J. W. Gregory, who informs me that the nomenclature of the Polyzoa (both genera and species) is in a very unsettled state.

The nomenclature of the Lamellibranchiate Mollusca is also greatly in need of revision. The species of *Pecten* and *Lima* mentioned in the following list are especially open to correction: thus, the names *elongatus* (Lam.), and *Raulinianus* (D'Orb.), are attached to certain *Pectens* in most of the museums, but I doubt if they are correctly so named. Again, the *Pecten* I have called *P. Galliennei* (D'Orb.), has usually been named *P. interstriatus* (Leym.), although D'Orbigny pointed out in his Prodrome that Leymerie's name was given to another *Pecten* by Munster in 1841. Moreover, the species occurring at Warminster agrees more closely with that named *Galliennei* by D'Orbigny, than with the Aptian form which he renamed *Aptiensis*.

With respect to the *Limæ* I have united those which are named *L. globosa* and *L. albensis* in different museums, though it is possible there are two species. I have also entered under the head of *L. ornata* (D'Orb.), some which have been named *L. Rauliniana* (D'Orb.), which is a kindred but different species.

LIST II.

FOSSILS FROM THE RYE HILL SAND.

	Jermyn Street.	British Museum.	Woodwardian Museum.	Devizes Museum.	Bristol Museum.	Bath Museum.	Range.
Reptilia.							
Ichthyosaurus campylodon, Carter	x	—	—	—	—	—	d. and up
Polyptychodon interruptus, Owen	x	—	—	—	—	—	d. and up
Pisces.							
Corax heterodon, Reuss	x	—	—	—	—	—	up
Edaphodon crassus, Newton	x	—	—	—	—	—	
Enchodus halocyon, Ag.	x	—	—	—	—	—	d. and up
Lamna appendiculata, Ag.	x	—	—	—	—	—	d. and up
,, gracilis, Ag.	x	—	—	—	—	—	d. and up
,, subulata, Ag.	x	—	—	—	—	—	d. and up
Oxyrhina Mantelli, Ag.	x	—	—	—	—	—	up
Plethodus expansus, Dixon	x	—	—	—	—	—	d. and up
Protosphyræna ferox, Leidy	x	—	—	—	—	—	d. and up
Ptychodus decurrens, Ag.	x	—	—	—	—	—	up
Pycnodus cretaceus, Ag.	x	—	—	—	—	—	
Cephalopoda.							
Belemnitella ultima, D'Orb.	x	—	—	—	—	—	d. and up
,, sp.	x	—	x	—	—	—	
Nautilus expansus, Sow.	—	—	x	—	—	—	up
,, subradiatus (?), D'Orb.	x	—	—	—	—	—	d. and up
,, sp.	—	—	—	x	—	—	
Ammonites curvatus, Mant.	x	x	—	—	—	—	up
,, falcatus, Mant.	x	x	x	x	—	—	up
,, complanatus, Mant....	—	x	—	—	—	—	up
,, Mantelli, Sow....	x	x	x	—	—	—	up
,, navicularis, Mant.	—	x	—	—	—	—	up
,, planulatus, Sow.	—	x	—	—	—	—	d. and up
,, varians, Sow.	x	x	x	x	—	—	up
,, ,, *var.* Coupei, Brong....	x	x	x	x	—	—	up
Hamites Parkinsoni (?), Flem.	—	—	x	—	—	—	?
,, sp.	x	—	—	—	—	—	
Turrilites Wiestii, Shpe.	—	—	x	—	—	—	up
,, Morrisii, Shpe.	—	—	x	—	—	—	up
Baculites baculoides, D'Orb.	x	—	—	—	—	—	up
Gasteropoda.							
Aporrhais oligochila, Gardner	—	x	—	—	—	—	up
,, sp.	x	—	—	—	—	—	
Fusus bilineatus (?), Pict. and R.	—	—	x	—	—	—	d. and up
Gibbula levistriata, Seeley	—	x	x	—	—	—	d. and up
Littorina, sp.	—	x	—	—	—	—	
Pleurotomaria allobrogensis, D'Orb.... ..	—	x	—	—	—	—	
,, Mailleana, D'Orb.	—	—	x	—	—	—	up

	Jermyn Street.	British Museum.	Woodwardian Museum.	Devizes Museum.	Bristol Museum.	Bath Museum.	Range.
Pleurotomaria perspectiva (?), Mant.	—	x	x	—	x	—	up
,, Rhodani, D'Orb.	—	x	—	—	—	—	d. and up
,, Thurmanni (?), P. and R. ...	—	—	x	—	—	—	d. and up
,, vraconnensis (?), P. and C.	—	—	x	—	—	—	?
,, sp.	x	—	—	—	—	—	
Solarium ornatum, Sow.	—	x	—	—	—	—	d. and up
Trochus variabilis, Seeley {=cancellatus, Seeley, and indecisus, D'Orb.)	—	—	x	—	—	—	d. and up
Scalaria, sp. (casts)	x	—	x	—	—	—	
Turritella, sp.	x	—	—	—	—	—	
Lamellibranchs.							
Anomia, like convexa, Sow.	x	—	—	—	—	—	
,, like radiata, Sow.	x	—	—	—	—	—	
Avicula gryphæoides, Sow.	x	—	—	—	—	—	d. and up
Exogyra conica, Sow.	x	x	x	x	x	x	d. and up
,, haliotoidea, Sow.	—	—	x	—	—	x	d. and up
Ostrea canaliculata, Sow. (=O. lateralis, Nilsson)	x	—	—	x	—	—	d. and up
Ostrea carinata, Sow. (=frons, Park.) ...	x	x	x	x	—	—	d. and up
,, vesicularis, Lam.	x	—	—	x	—	—	d. and up
Pecten asper, Lam.	x	x	x	x	x	x	d. and up
,, elongatus (?), Lam.	x	—	x	x	—	—	
,, Galliennei, D'Orb....	x	x	x	x	x	—	down
,, like fissicosta, Eth.	—	—	—	x	—	—	
,, orbicularis, Sow.	x	x	x	—	—	x	d. and up
,, Puzosianus, D'Orb.	x	—	—	—	—	—	up
,, like Raulinianus, D'Orb.	x	—	x	x	—	—	
Janira æquicostata, Lam.	x	?	—	—	—	—	d. and up
,, cometa, D'Orb.	x	x	x	—	—	—	up
,, quinquecostata, Sow.	x	—	x	x	—	—	d. and up
Hinnites, sp.	x	—	—	—	—	—	
Plicatula inflata, Sow., variety of P. pectinoides, Sow....	x	—	x	x	—	x	d. and up
Lima asper (?), Mant.	x	—	x	—	—	—	up
,, cenomanensis, D'Orb.	x	—	—	x	—	—	up
,, compositus (?), Sow....	—	x	—	—	—	—	down
,, globosa, Sow.	x	—	—	x	—	—	d. and up
,, intermedia (?), D'Orb.	x	x	x	x	—	x	up
,, ornata, D'Orb.	x	x	x	—	—	—	up
,, rothomagensis (?), D'Orb.	x	—	—	—	—	—	
,, semiornata, D'Orb.	x	—	—	x	—	—	up
,, simplex (?), D'Orb.	—	—	x	—	—	—	
,, new sp.	x	—	—	—	—	—	
Spondylus striatus, Sow.	x	x	x	x	—	x	up
,, like hystrix, D'Orb.	—	—	x	x	—	—	
Inoceramus latus, D'Orb. (*non* Sow.) ...	x	—	?	—	—	—	up
,, sp.	x	—	—	—	—	—	
Lithodomus, sp.	x	—	—	—	—	—	
Modiola, sp....	x	—	—	—	—	—	
Trigonia aliformis, Park.	x	—	x	—	—	—	down
,, spinosa (?), Park....	x	—	x	—	—	—	down
Arca mailleana, D'Orb.	x	—	x	—	—	—	d. and up
Cyprina quadrata, D'Orb.	x	—	?	—	—	—	up
Crassatella regularis (?), D'Orb.	x	—	—	—	—	—	
Cypricardia, sp.	x	—	—	—	—	—	

	Jermyn Street.	British Museum.	Woodwardian Museum.	Devizes Museum.	Bristol Museum.	Bath Museum.	Range.
Pholadomya, sp.	x	—	—	—	—	—	
Panopæa, sp.	x	—	—	—	—	—	
Solecurtus, sp.	x	—	—	—	—	—	
Brachiopoda.							
Argiope megatrema, Sow.	—	—	—	—	x	—	up
Lingula subovalis, Dav.	—	x	—	—	—	—	down
Megerlia lima, Defr.	x	—	—	x	—	—	d. and up
Rhynchonella convexa, Sow.	x	x	x	x	x	x	d. and up
,, dimidiata, Sow.	x	x	x	x	x	—	d. and up
,, Grasiana, D'Orb.	x	x	x	x	x	x	up
,, Mantelliana, Sow.	x	—	x	—	—	—	up
,, Martini, Sow.	x	x	—	—	—	—	up
,, sulcata (?), Park.	—	x	—	—	—	—	down
,, Schloenbachi, Dav.	x	x	—	—	—	—	d. and up
Terebratula biplicata, Sow.	x	x	x	x	x	x	d. and up
,, obesa, Sow.	x	x	x	—	x	—	up
,, ovata, Sow.	x	x	x	—	—	—	down
,, phaseolina (?)	—	—	x	—	—	—	down
,, squamosa, Mant.	x	—	—	—	—	—	up
Terebratulina gracilis, Schloth....	x	—	—	—	—	—	up
,, striata, Wahl.	x	x	x	—	x	—	d. and up
Terebratella pectita, Sow.	x	x	x	x	x	x	d. and up
,, Menardi, D'Orb.	—	—	x	—	—	—	d. and up?
Rhynchora lyra, Sow.	x	—	x	x	x	—	up
Waldheimia, like Juddii, Walker	x	—	—	—	—	—	
Polyzoa.							
Bidiastopora lamellosa, D'Orb.	x	—	—	—	—	—	
Ceriopora polymorpha, Goldf.	x	—	—	—	—	—	
Choristopetalum impar, Lons.	x	—	—	—	—	—	
Clausa micropora, D'Orb.	x	—	—	—	—	—	
Diastopora Sowerbyi, Lons.	x	—	—	—	—	—	
,, tubulus (?), D'Orb.	x	—	—	—	—	—	
,, sp.	x	—	—	—	—	—	
Entalophora ramosissima, D'Orb.	x	—	—	—	—	—	
,, cenomana, D'Orb.	x	—	—	—	—	—	
,, sp.	x	—	—	—	—	—	
Eschara cybele (?), D'Orb....	x	—	—	—	—	—	
,, sp.	x	—	—	—	—	—	
Heteropora, sp.	x	—	—	—	—	—	
Radiopora pustulosa, D'Orb.	x	—	—	—	—	—	
Spiropora cenomana, D'Orb.	x	—	—	—	—	—	
Truncatula pinnata, Röm.	x	—	—	—	—	—	
Crustacea.							
Cyphonotus incertus, Carter	—	x	—	—	—	—	down
Necrocarcinus Bechei, Deslong.	x	—	—	x	—	—	down
,, tricarinatus, Bell	—	x	—	—	—	—	down
,, Woodwardii, Bell...	—	x	x	x	—	x	down
Hemioon Cunningtoni, Bell	—	x	—	x	—	—	down
Plagiophthalmus oviformis, Bell	—	x	—	x	—	—	
Hauthosia gibbosa, Bell	—	x	—	x	—	—	
Crustacean claws	—	—	—	x	—	—	
Scalpellum lineatum, Darw.	x	—	—	—	—	—	up
Pollicipes, sp.	x	—	—	—	—	—	

	Jermyn Street.	British Museum.	Woodwardian Museum.	Devizes Museum.	Bristol Museum.	Bath Museum.	Range.
Annelida.							
Ditrupa difformis, Lam.	x	—	—	—	—	x	up
Galeolaria filiformis, Sow.	x	x	x?	x	—	—	d. and up
,, plexus, Sow.	x	x	—	—	x	—	d. and up
Serpula ampullacea, Sow.	x	x	—	—	—	—	d. and up
,, annulata, Reuss	x	—	—	—	—	—	up
,, antiquata, Sow.	x	x	x?	—	x	x	d. and up
,, ilium, Sow.	x	—	—	—	—	—	up
,, macropus	x	—	—	—	—	—	
,, plana, Woodw.	x	—	—	—	—	—	up
Vermicularia concava, Sow.	x	—	x	—	—	—	down
,, umbonata, Sow.	x	—	—	—	—	—	d.? and up
Echinodermata.							
Cidaris vesiculosa, Goldf.	x	x	x	x	—	—	up
,, velifera, Ag.	—	x	—	—	—	—	
Cottaldia Benettiæ, König	x	x	x	x	—	x	
Discoidea subuculus, Leske	x	x	x	x	—	x	d. and up
Echinocyphus difficilis, Ag.	x	x	x	—	—	—	up
Glyphocyphus radiatus, Hön.	—	x	—	—	—	—	up
Goniophorus lunulatus, Ag.	x	x	x	x	—	—	up
Peltastes clathratus, Ag.	x	x	x	x	—	x	up
,, umbrella, Ag.	x	x	x	x	—	—	up
Pseudodiadema Benettiæ	x	x	x	x	—	x	up
,, Michelini, Ag. (= Ps. Bonei, Forbes)	x	x	x	x	—	x	
Pseudodiadema Rhodani, Ag.	x	x	—	x	—	—	
,, variolare, Brong.	x	x	x	x	—	—	up
Salenia petalifera, Desor	x	x	x	x	—	—	up
,, gibba, Ag.	—	x	—	x	—	—	
,, Desori, Wright	—	x	—	—	—	—	
,, Lorioli, Wright	—	x	—	—	—	—	
Caratomus rostratus, Ag.	x	x	x	—	—	x	
Cardiaster fossarius, Benett	?	x	x	—	x	x	down
Catopygus columbarius, Lam.	x	x	x	x	x	x	d. and up
Echinobrissus lacunosus, Goldf.	x	x	x	x	—	—	down
,, Morrisii, Forbes	—	x	—	—	—	—	? down
Holaster lævis (*var.* carinatus)	x	x	—	x	x	—	d. and up
,, subglobosus, Leske	x	—	—	x	—	—	up
Hemiaster minimus, Ag.	x	x	x	—	—	—	d. and up
Pyrina lævis, Ag. (Dr. Wright's coll.)	—	—	—	—	—	—	
Pentacrinus Agassizi, Hagenow	x	x	x	x	x	—	up
Glenotremites paradoxus, Goldf.	x	—	—	—	—	—	
Actinozoa.							
Micrabacia coronula, Goldf.	x	x	—	x	—	x	up
Astrocœnia decaphylla, E. and H.	x	—	—	—	—	—	?
Stephanophyllia Bowerbankii, M. Edw.	x	x	—	—	—	—	up
Trochosmilia, sp.	x	—	—	—	—	—	
Hydrozoa.							
Porosphæra urceolata, Phil.	x	—	—	—	—	x	d. and up
Parkeria, sp.	—	—	—	x	—	—	
Spongida.							
Trematocystia Orbignyi, Hinde	x	x	x	—	—	—	
,, siphonioides, Mich.	—	x	—	—	—	—	

When we come to study the components of this fauna we find it to be a curious mixture of species, many of them being species which are common in the Chalk Marl, and are not known to occur below this particular bed of sand or its equivalent on the south coast, while others are species which do not range higher, or are, at any rate, not found in the Chalk Marl. Considering the stratigraphical position of the Rye Hill Sand and the upward passage from it to the Chloritic Marl, it is not surprising to find that the fauna also exhibits a transitional character. It will, however, be useful to discuss the evidence afforded by the members of each class or order separately.

Cephalopoda.—All the Ammonites and most of the other Cephalopods are species which characterize the true Chloritic Marl (zone of *Stauronema Carteri*) and the Chalk Marl (zone of *Ammonites varians*). So far as my experience goes, none of them, except *Belemnitella ultima*, *Nautilus subradiatus*, and *Ammonites planulatus*, range down to lower horizons.

Gasteropoda.—It is doubtful how many of these really occur in the Rye Hill Sand; they are certainly rare, and most of those in museum collections have come from the Chloritic Marl. Of those admitted to my list, the range of most is probably upward as well as downward.

Lamellibranchiata.—The distribution of these is remarkable; only four of them range down, no less than 10 have an exclusively upward range, while 12 range both up and down, and six are doubtfully identified with French Cenomanien species. This part of the fauna, then, has decidedly closer relations with that of the Chalk Marl than with that of the Greensand.

Brachiopoda.—Of these, again, only four are exclusively Greensand species; and one of these, the supposed *Rhynchonella sulcata*, is probably an extreme variety of *Rh. dimidiata*. Seven species belong decidedly to the Lower Chalk fauna, and eight are believed to range both up and down.

Crustacea.—Of these, five range down to the Gault, two are peculiar to the Rye Hill Sand, and only *Scalpellum lineatum* ranges into the Chalk. The Brachyurous Crustacea seem, therefore, to be the relics of an older fauna, and as none have yet been found in the Chalk Marl it would seem as if the physical conditions of that deposit were unsuitable to them.

Annelids.—These are long-lived creatures, but most of the species in the list range upward; and though some range down as well, only one is specially a Greensand species.

Echinodermata.—Out of a total of 28 species nine are rare fossils, either unknown elsewhere in England at present, or found only in the Cenomanian of Devon. Deducting these nine, the remainder is 19; and of these, 11 range upward, occurring either in Chloritic Marl or Chalk Marl, five range both up and down, while only three are not known to occur at higher horizons. One of the last, *Cardiaster fossarius*, is very characteristic of the higher part of the Upper Greensand in the south and south-west of England. It is common in the Chert Beds near Warminster, but seems rather rare in the Rye Hill Sand.

No fewer than 13 of the species occur in the Chalk Marl, and it is clear that there is a preponderating Chalk Marl element in the Echinoid fauna of the Rye Hill Sand. The fact has been noted before, though it has not been stated correctly; thus, Dr. Wright, in his Monograph on the Cretaceous Echinodermata, makes the following remarks: "I have long noticed nearly all the Upper Greensand Echinidæ are found in the Grey Chalk, and that the specimens from the latter stratum are in general larger and more fully developed, as if they had been better nourished, than those collected from the arenaceous beds of the Upper Greensand of Wiltshire and other localities."

The mistake Dr. Wright and everyone else have made is in regarding all these Warminster Echinoderms as characteristic Upper Greensand species. They are really Chalk Marl species, and the very topmost bed of the Greensand at Warminster and elsewhere is, for many of them, *the limit of their downward range*. In other words they are not Greensand species, but Chalk species which make their first appearance at this horizon.

Actinozoa.—Only four corals have been obtained from the Rye Hill Sand, and three of these are Chalk forms, the fourth being *Astrocænia decaphylla*, for which the only other known locality is Haldon, in Devonshire, and as the coral bed there is at the top of the Greensand it may not be older than the Rye Hill Sand.

Reviewing the above palæontological evidence, we find that the total number of species which range up into the Chalk Marl is much greater than the number of those which range down through the Upper Greensand, and this is so after the exclusion of many species which have hitherto been admitted as Warminster fossils, but which really came from the Chloritic Marl. Roughly speaking and setting aside those which range both ways, the species ranging upward are nearly three times as many as those ranging downward.

If the Rye Hill Sand were only known as an outlying patch, situated further west, and we had only the evidence of the fossils to guide us in determining its geologic age, it might have been regarded as a shallow-water deposit of the age of the Chalk Marl, and the Ammonites might have been appealed to as strong evidence in support of the contention. Nor would the conclusion have been very far wrong, for the bed is only just below the Chalk Marl.

This preponderance of upward-ranging species in the Rye Hill Sand accounts for the idea put forward in 1874 by Mr. C. J. A. Meyer[1] that "the fossiliferous portion of the so-called Upper Greensand of Warminster is, properly speaking, 'Chloritic Marl,' instead of 'Upper Greensand,' as usually stated." Judging from the collections of Warminster fossils seen in museums, and without the stratigraphical knowledge which has since been obtained, it was a very natural conclusion on his part, though it is not strictly correct.

The limitation of the so-called Warminster fauna to a few feet at the top of the Upper Greensand has an important bearing on the Cenomanian question, for it will show our French *confrères*

[1] Quart. Journ. Geol. Soc., vol. xxx, p. 381.

that the fauna which they rightly regard as so essentially Cenomanien, is not a typical Upper Greensand fauna, nor even the fauna of the Greensand chert beds; but is the fauna of a special bed which lies only just below the horizon that is taken by Mr. Hill and myself as the base of the Cenomanian both in France and England.[1]

The fact that this bed contains so many precursors of the Chalk Marl (or Cenomanian) fauna does not seem to me a sufficient reason for excluding it from the Upper Greensand; though doubtless most French geologists would think so. D'Orbigny's doctrine, that every system can be divided into stages, the faunas of which are sharply marked off from one another, has greatly influenced French opinion, and they still seem to have a tendency to put a higher value upon the evidence of fossils than upon other lines of evidence.

My own experience as a field geologist has taught me that exposures which are twenty or thirty miles apart, generally show some little differences in the distribution of fossils, above and below any line of separation which can be taken between two stages. When localities are still further apart, the range of species differs more; no one now supposes that a species appeared everywhere at the same epoch of time, and we must not allow the evidence of fossils to override plain stratigraphical facts.

Appendix.

The following is a list of the species to which the specimens preserved in brownish phosphate included in many collections of Warminster fossils belong. It will be seen that many species have been excluded on this account from the previous lists; but there is no doubt that some occur both in the matrix of the Rye Hill Sand and in that of the Chloritic Marl, though all are more common in the latter.

Ammonites Coupei, Brong.
,, curvatus, Mant.
,, falcatus, Mant.
,, complanatus?
,, Mantelli, Sow.
,, navicularis, Mant.
,, planulatus, Sow.
,, varians, Sow.
Scaphites æqualis, Sow.
Turrilites Bergeri, Brong.
,, costatus, Lam.
,, Gravesianus, D'Orb.
,, Morrisii, Sharpe.
,, tuberculatus, Bosc.
Nautilus Deslongchampsianus, D'Orb.
,, Fittoni, Sharpe.
Avellana cassis.
Aporrhais Parkinsoni? and other species.
Columbellina, sp.
Emarginula Gresslya, P. and C.
,, sp.
Dentalium ellipticum, Sow.
Crepidula, sp.
Fusus bilineatus?
,, sp.
Pleurotomaria Rhodani, D'Orb.
,, Thurmanni, P. and R.
,, vraconnensis, P. and C.
Phasianella, sp.
Turbo, sp.
Solarium Martinianum, D'Orb.
,, dentatum, D'Orb.
,, ornatum, Sow.
Scalaria Rauliniana, D'Orb.
Natica gaultina, D'Orb.
Pterocera inflata, D'Orb.
Cucullæa glabra, Park.
,, ligeriensis?, D'Orb.
Arca Mailleana, D'Orb.
Cyprina quadrata, D'Orb.
Unicardium Ringmeriense, Mant.
Nucula pectinata, Sow.
Lutraria carinifera, D'Orb.
Catopygus columbarius, Lam.

[1] See Quart. Journ. Geol. Soc., vol. lii, pp. 105, 119.

REVIEWS.

I.—The Extinct Vertebrata of the Moray Firth Area. By R. H. Traquair, M.D., LL.D., F.R.S. [Reprint from Brown and Buckley's "Vertebrate Fauna of the Moray Basin" (Edinburgh, 1896), pp. 235–285, pls. i–ix.]

MESSRS. BROWN AND BUCKLEY have done good service to Vertebrate Palæontology by inducing Dr. Traquair to contribute to their recently published volume on the vertebrate animals of the Moray Basin, a summary of the known fossil fishes from the Old Red Sandstone of that area. The supplement occupies fifty pages, and is illustrated by nine plates of Old Red fishes drawn by Dr. Traquair himself; only ten pages of it are devoted to the enumeration of the vertebrata of the Triassic, Jurassic, and Pleistocene deposits. Six of the nine plates are occupied with useful restorations, some already published elsewhere, but the majority quite new, and giving a much more correct idea of the Old Red Sandstone fishes than any restorations previously attempted. They are only marred by the process of reproduction, which imparts to them an inartistic coarseness.

After some preliminary remarks on the distribution and divisions of the Old Red Sandstone in the Moray Basin, accompanied by an enumeration of the literature of the subject, Dr. Traquair proceeds to treat of the fishes of the Lower Old Red Sandstone (Orcadian Series). They are systematically arranged, though not technically described; and the known localities for each species are carefully enumerated. The Acanthodians are named *Diplacanthus striatus*, *D. tenuistriatus*, *Rhadinacanthus longispinus*, *Mesacanthus pusillus*, *Cheiracanthus Murchisoni*, and *C. latus*. Restored figures of *Diplacanthus* and *Cheiracanthus* are added. The subclass Ostracodermi and the order Antiarcha are admitted, three species of *Pterichthys* (*Milleri*, *productus*, and *oblongus*) being recorded here. Of the Dipnoi, the sole representative is *Dipterus Valenciennesi*, of which a new restoration is given. Though common in the Caithness Flags, this fish is very rare in the Moray Firth area. The subclass Teleostomi (Dr. Traquair no longer speaks of Ganoidei) includes *Glyptolepis leptopterus*, *Gyroptychius microlepidotus*, *Osteolepis macrolepidotus*, *Diplopterus Agassizi*, and *Cheirolepis Trailli*, while the characters of all, except the first, are shown in restored figures. The "Order Placodermata" is placed "incertæ sedis" under the Teleostomi. *Coccosteus decipiens* and *Homosteus Milleri* are recorded here, the first a very common fish, the second known in the Moray area only from Hillhead quarry, near Dalcross.

The fishes of the Upper Old Red Sandstone of Moray are shown to represent two distinct faunas—that of Nairn in the west, that of Elgin in the east. These are treated separately, and a table of localities at the end indicates at a glance the species found in each. The first species mentioned from Nairn, *Asterolepis maxima*, was described by Dr. Traquair in great detail in the Palæontographical

Society's volume for 1894. The three remaining species are known only by fragments, but seem to be new to the locality, if not entirely new. Some detached scales (one figured) are identified with *Holoptychius decoratus*, Eichwald, sp., from Wenden, Livonia. Imperfect Rhizodont jaws are described and figured as *Polyplocodus leptognathus*, sp. nov.; while the anterior median ventral plate of a large Coccostean is regarded as indicating a new species, *Coccosteus magnus*. The species from the Elgin district are more numerous and more interesting. The curious Elasmobranch armour-plates described nearly two years ago as *Psammosteus Taylori*, are treated in detail, and Dr. Traquair incidentally gives the new generic name, *Turinia*, to the *Cephalopterus* of Powrie (preoccupied 1809) from the Lower Old Red Sandstone of Turin Hill, Forfar. There are further valuable notes on the Elasmobranch spine, *Cosmacanthus Malcolmsoni*, which proves to be a paired spine, not bilaterally symmetrical as supposed by Agassiz. A restored outline of *Bothriolepis major* is given, and this is described as the largest known Asterolepid, the total length of the armour being sometimes probably not less than a foot and a half. Three portions of armour from Rosebrae Quarry, near Elgin, are regarded as indicating another species, *Bothriolepis cristata*, sp. nov., distinguished by an elevated crest on its dorsal surface. *Phyllolepis concentrica*, *Conchodus ostreiformis*, and *Holoptychius nobilissimus* are merely recorded; but a figure of *Holoptychius Flemingi* (from Dura Den, Fifeshire) is added to complete the series of restorations. *Holoptychius giganteus* is believed to claim many detached teeth besides the characteristic scales. Fragments of jaws seem to belong to *Polyplocodus*; and a brief reference to *Glyptopomus minor* concludes the enumeration.

We hope this is only the forerunner of a more extensive work on the Palæozoic Fishes of Scotland, which would summarize the results of Dr. Traquair's numerous papers, and make them more readily accessible to non-specialists. Most geological and biological handbooks still display lamentable ignorance of the subject, and a general treatise like the present would do much towards enlightenment. A. S. W.

II.—Mollusques Éocéniques de la Loire-Inférieure. By M. Cossmann. (Bull. Soc. Sci. Nat. Ouest France, 1895, Tome V, pp. 159–197, Plates v–vii, Fascicule 1.)

M. COSSMANN, who undoubtedly ranks as the leading Tertiary Malacologist of France, is preparing a Monograph of the Eocene Molluscan fauna of Brittany, the first part of which is now before us. The majority of the shells have been obtained from special excavations made at Bois-Gouët, in the Saffré Basin, under the direction of M. Dumas; others have been collected at Coislin and La Close, near Camphon; whilst the remainder come from the dolomitic district of Arthon. These different localities, situated in the department of La Loire-Inférieure, have yielded a number of new species as well as all those listed in Vasseur's

treatise, "Recherches Géologiques sur les terrains tertiaïres de la France occidentale": Stratigraphie, first part. Bretagne (Annales Sciences Géologiques, 1881, vol. xiii). Many of the shells in Vasseur's work have hitherto had only a manuscript value, as the intention of that author to fully describe and figure them in a second part was never realized, if we except a few plates of fossils which were subsequently issued without text. Although through courtesy the name of Vasseur is still attached to these species, now described for the first time, there is no doubt that M. Cossmann must claim their real authorship.

The present work, judging from this first part, promises to be a large and important one, as all the species, whether new or otherwise, are fully diagnosed and figured. A large number of the shells, we are told in the preliminary remarks, can be undoubtedly paralleled with Paris Basin forms; a few being of Lower Eocene age, whereas the majority belong to the upper portion of the Middle Eocene. The groups now considered are: the Cephalopoda and the Pulmonate and Opisthobranchiate Gasteropods.

One of the most interesting facts brought out with reference to the Cephalopoda is the discovery of a second specimen of James de Carle Sowerby's *Beloptera anomala*; the only known example prior to this was the type specimen from the London Clay at Highgate, upon which Frederick Edwards founded the genus *Belemnosis*. The principal distinguishing character of the genus, according to Edwards, was the large aperture "which forms a communication between the alveolar chambers and the sac in which the shell was lodged." If such an aperture were normal, it would constitute a serious anomaly in the organization of the Cephalopoda; and Messrs. R. B. Newton and Geo. F. Harris suggested that it was due to the imperfection of the Highgate specimen, which bears traces of having been rolled. The last-mentioned authors showed that the so-called ventral aperture was in reality only the initial chamber of the shell brought to light by the removal of a thin projecting part of the rostrum consequent on ill-usage. It is interesting to note that the more perfect specimen discovered by M. Cossmann, and described in the work under review, fully bears out the theoretical conclusions of Messrs. Newton and Harris. The latter, however, included the species in the genus *Spirulirostra*. M. Cossmann thinks that the points of difference are of sufficient importance to warrant the retention of Edwards' generic name: "les *Belemnosis*," he remarks, "sont des *Spirulirostra* sans rostre, et à phragmocône moins spiral." Without analyzing afresh the interesting details brought forward by Messrs. Newton and Harris respecting the generic position of this shell, we are inclined to accept their theory; the question of the length of the rostrum or whether it is obtuse or pointed, not being, in our view, a prime generic factor. Out of fifty-five shells reviewed, the following are recorded as new species:—CEPHALOPODA: *Belosepia Dufouri*. GASTEROPODA (PULMONATA): *Limnæa Bourdoti, L. Gouëtensis, L. adela; Bulimus Dumasi; Auricula namnetica, A. simplex, A. Heberti,*

A. Monthiersi, A. citharella, A. Ludovici, A. Douvillei, A. Houdasi; *Scarabus Bonneti*; *Ophicardelus sinuosus*; *Marinula labrosa*; *Siphonaria Tournoueri, S. granicosta.* GASTEROPODA (OPISTHOBRANCHIATA): *Actæon Octavii, A. Dumasi*; *Crenilabium suturatum*; *Scaphander tenuistriatus*; *Bullinella brachymorpha, B. Rideli*; *Plicobulla* (subgen. nov.) *Dumasi*; *Cylichnella Bourdoti*; *Amphisphyra subcylindrica*; *Ringicula Morleti.*

III.—PROF. G. VICENTINI ON EARTHQUAKE-PULSATIONS.

(1) "Osservazioni e Proposte sullo studio dei Movimenti Microsismici": Atti della R. Accad. dei Fisiocritici (Siena), v, 1894.

(2) "Microsismografo a registrazione continua; Cenno sui movimenti sismici dei giorni 14 e 15 Aprile, 1895": Bullettino della Soc. Veneto-Trentina di Scienze Naturali (Padova), vi, 1895, pp. 5–12.

(3) "Microsismografo a registrazione continua": Bollettino della Soc. Sismologica Italiana, i, 1895, pp. 66–72.

(4) "Osservazioni sismiche": Atti della R. Accad. dei Fisiocritici (Siena), v, 1894.

(5) "Movimenti sismici registrati dal microsismografo nella prima metà del luglio 1894": *ibid.*

(6) "Intorno ad alcuni fatti risultanti da osservazioni microsismiche": Atti e Memorie della R. Accad. di Scienze, etc., in Padova, xii, 1896, pp. 89–97.

In the first three of these papers, Prof. Vicentini describes the instrument with which his investigations have been made at Siena and Padua; the fourth and fifth contain an account of the records at Siena from February 17 to July 14, 1894, and are accompanied by copies of some of the more interesting diagrams; the last and most valuable of the series summarizes the conclusions at which he has so far arrived.

The microseismograph is a heavy pendulum, about $1\frac{1}{2}$ metres (or a little less than five feet) in length. The centre of the base of the mass which forms the bob of the pendulum is connected with the upper end of the short arm of a light vertical lever, so that every movement of the mass is magnified by the lower end of the lever. A further magnification is obtained by means of two horizontal levers at right angles to one another, the shorter arms of which are connected with the lowest point of the vertical lever. The other ends of the horizontal levers consist of sharp points, which rest lightly on a strip of smoked paper driven underneath them by clockwork. When the pendulum is at rest, these points trace straight lines upon the paper. When it is disturbed in any manner, the path of the centre of the heavy mass is determined by combining the curves traced by the two points.

The cost of the paper on which the records are made being very small, an unusually rapid movement can be allowed, and thus the diagrams are to a great extent free from that confusion caused by overlapping which can hardly be avoided when the more expensive process of photographic registration is employed.

The character of the diagrams is found to depend on the strength

of the earthquake and on the distance of the place of observation from the epicentre.

In the case of slight local earthquakes, the first movements are rapid vibrations superposed on small oscillations of longer period. When the vibrations cease, the oscillations become more marked, and, as a rule, the mean position of the pendulum undergoes a continuous change, showing that the ground receives a tilt which, after reaching a maximum value, disappears more or less slowly. On May 25th, 1895, for example, a slight earthquake occurred at Rovigo, which lies about twenty miles south of Padua. Joining the mean points of all the oscillations recorded by the two pens, the components are obtained of the path along which the pendulum would have moved if it had followed the tilts of the ground slowly and without oscillating. The resultant path is found to be nearly a straight line running N. 32° W. and S. 32° E. During the first ten seconds the tilt of the ground took place slowly; in the next twelve seconds it rapidly increased to a maximum of about 6″; and then, during the next ten seconds, it returned as rapidly towards its original position, which, however, it only reached after other small oscillations of about twenty seconds' duration.

The more distant the epicentre, the longer is the first phase of the movement, namely, that which consists of rapid vibrations superposed on small oscillations. As a rule, both of these take place about a line indicating a very slight tilt of the ground. If the shock be strong and the epicentre distant, this first phase may last for about a minute. The second phase consists of large oscillations with various maxima, which begin and end suddenly. The third and last phase is characterized by small irregular oscillations, much slower than the preceding. Throughout both of these phases, the mean position of the pendulum continually changes, as if long, slow waves, with a period of at least twenty seconds, were at the same time propagated across the ground.

In the diagrams corresponding to disastrous shocks with a very distant epicentre (such as, for example, the Japanese and Argentine earthquakes of 1894), the different phases of the movement are separated from one another. The first consists of vibrations, of abrupt displacements, and small oscillations; in the second phase, the lines are irregular and deeply sinuous, though interrupted by sudden displacements of small amplitude; while, in the third, the lines become regular and sinuous, indicating a slow and gentle rocking of the ground with a period of about thirty seconds.

C. Davison.

IV.—Fish-remains from Phosphatic Chalk in France. (Sur les Poissons de la Craie Phosphatée des Environs de Péronne.) By F. Priem. Bull. Soc. Géol. France [3], vol. xxiv, pp. 9-23, pls. i, ii (1896).

THE stratigraphical distribution of fossil fishes in the Chalk is a subject deserving more careful attention than it has hitherto received. Detailed descriptions of remains from definite horizons

are thus very welcome, and M. Priem's recent paper on teeth and other fragments from the phosphatic chalk of Péronne, Somme (zone of *Belemnitella quadrata*), is an interesting contribution of this kind. The author is a pupil of Prof. Gaudry, and has determined the specimens in the Laboratory for Palæontology in the Jardin des Plantes, Paris. The species represented are *Ptychodus latissimus*, *Oxyrhina Mantelli*, *Lamna appendiculata*, *Scapanorhynchus* (*Odontaspis*) *rhaphiodon*, *S.*? (*O.*) *subulatus*, *Corax pristodontus*, and a form of *Protosphyræna*, possibly *P. ferox*. The two illustrative plates are beautiful photographs of the actual fossils.

REPORTS AND PROCEEDINGS.

Zoological Society of London.

March 17th, 1896.—Prof. G. B. Howes, F.Z.S., in the Chair.

Mr. A. Smith Woodward, F.Z.S., read a paper on some extinct fishes of the Teleostean family Gonorhynchidæ. He described a new specimen of *Notogoneus osculus* from the Eocene (Green River Shales) of Wyoming, U.S.A., confirming Cope's determination of this fish as a member of the family Gonorhynchidæ. He also pointed out that the so-called *Sphenolepis squamosseus* and *S. Cuvieri*, imperfectly described by Agassiz from the Eocene of France, are generically identical with *Notogoneus*. In proof of this identification, he gave an account of new specimens in the British Museum. The Gonorhynchidæ were thus shown to have comprised fresh-water fishes in the early Tertiary period both in Europe and North America.

Geological Society of London.

I.—April 15th, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair.

The President announced that a portrait in sepia of Prof. Bonney, executed by Mr. Trevor Haddon, had been presented to the Society by 34 subscribers, Fellows of the Society.

The following communications were read:—

1. "The Junction-Beds of the Upper Lias and Inferior Oolite in Northamptonshire.—Part I. Physical and Chemical." By Beeby Thompson, Esq., F.G.S., F.C.S.

The author, while combating the view that a considerable unconformity exists between the Upper Lias and the Inferior Oolite of Northamptonshire, brings together much evidence to illustrate the effects of slipping, and to show that these effects may be mistaken for those of unconformity. He also applies the evidence which he has collected to illustrate certain points in the physics of valley-formation.

After giving details as to the horizon of the springs of the district, the distribution of water in the Inferior Oolite, and the development

of the springs, he argues that every valley of the district has been elongated in the direction which it now has by a stream originating in a spring always at its head; and that the development of channels towards particular points of discharge has been the chief agent in initiating the formation and guiding the direction of all the minor valleys of the river-system within the influence of the same set of beds. A description of the characters of the slopes follows, and their significance is discussed. The structure of the hills and valleys of the district occupies the next portion of the paper, and the author considers that corresponding to the deepening of a valley by denudation there is uplifting of the beds below it, and at the same time an outward and upward thrust along the hillside which lifts beds there; also, that hills are reduced in height by sinking as well as by denudation of their upper parts. In discussing the question of unconformity between the Inferior Oolite and Upper Lias, the rarity of exposures of true junctions is noted, the junctions which have been chiefly examined by other observers being obscured by slipping; and reasons are given for inferring an absence of unconformity at the horizon, both on account of the character of the true junctions and from other considerations. The author, however, gives reasons for believing that a slight unconformity occurs in the Upper Lias, so that the lower part of the *jurensis*-zone is absent, and not its upper part as has been elsewhere inferred.

2. "Contributions to the Stratigraphy and Palæontology of the *Globigerina*-limestones of the Maltese Islands." By J. H. Cooke, Esq., F.L.S., F.G.S.

A bibliography of the *Globigerina*-limestones is followed by some remarks on the physical features and general distribution of the strata. The limestones are divided into nine subdivisions, lettered A to I, the former being uppermost. Four seams of phosphatic nodules form the subdivisions B, D, G, and I, and local nodule-bands also occur in E. The subdivision G serves as a line of demarcation between the Langhian Series (Miocene) and the Aquitanian (Oligocene). Details of the lithological and palæontological characters of the various subdivisions are given, and the author concludes that I, and the lower part of H, were laid down on a sinking sea-floor, in about 300 fathoms of water; that the upper part of H, and G, F, E, D, composed to a large extent of *Globigerina* and other pelagic organisms, were probably deposited in about 1000 fathoms; while C, B, and A, were probably laid down, like I, and the lower part of H, in about 300 fathoms of water.

3. "On the Geology of the Neighbourhood of Carmarthen." By Miss Margaret C. Crosfield and Miss Ethel G. Skeat. (Communicated by J. E. Marr, Esq., M.A., F.R.S., Sec. G.S.)

The area described lies approximately within a four-mile radius of Carmarthen. The beds of the district have been subjected to complicated foldings, amongst which an earlier set, giving rise to a number of small anticlines with north-and-south axes, and a later more extensive set, due to the series of earth-movements which

produced the great Condrusian ridge, producing anticlines and synclines having a general east-and-west trend, can be made out. The rocks forming the subject of the present paper occur in one limb of a complex anticline produced during the latter set of movements. In this limb beds of the following ages occur: Tremadoc Slates, Lower and Upper Arenig, Llanvirn, Llandeilo, and Bala. These beds are described in detail. A regular succession of strata from Tremadoc Slates to *Dicranograptus*-shales is found, while the Bala beds of Mount Pleasant abut on Arenig strata, and the reason for this irregularity has not yet been decided by the authors. The beds are compared with those of other areas. The Tremadoc Slates are equivalents of Stage 3*a* of the Christiania district; the Lower Arenig Beds with *Phyllograptus angustifolius*, and the Upper Arenig with *Didymograptus nitidus*, etc., resemble those of other British areas; the Llanvirn Beds contain *Didymograptus bifidus* and other fossils; the *Didymograptus Murchisoni*-beds are well known elsewhere. The Llandeilo Limestone is probably presented by sandy beds with *Asaphus tyrannus*; and the *Dicranograptus*-shales are like those of the Haverfordwest region. The Bala Beds of Mount Pleasant contain *Stygina Murchisonæ* and other fossils found elsewhere in Bala rocks.

A description of new fossils forms the concluding portion of the paper.

II.—April 29th, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair.

The following communications were read:—

1. "Descriptions of New Fossils from the Carboniferous Limestone.—(1) On *Pemmatites constipatus*, sp. nov., a Lithistid Sponge. (2) On *Palæacis humilis*, sp. nov., a new Perforate Coral; with Remarks on the Genus. (3) On the Jaw-apparatus of an Annelid, *Ennicites Reidii*, sp. nov." By George Jennings Hinde, Ph.D., F.G.S.

(1) The *Pemmatites*, belonging to a genus hitherto only known from the Permo-Carboniferous beds of Spitzbergen, was discovered in the Yoredale Beds of Yorkshire by Mr. J. Rhodes, and is the only fairly complete sponge which has hitherto been detected in the Yoredale Beds of North-west Yorkshire. The author gives a full description of the species.

(2) The *Palæacis* was found by the Rev. G. C. H. Pollen in the Carboniferous Limestone and Shale Series, on the banks of the Hodder, near Stonyhurst. The specific characters of the form are given by the author, who then remarks upon the genus *Palæacis*, which has been placed alternately with the corals and sponges, though latterly it has been generally regarded as a perforate coral. Nevertheless, its real characters had not been definitely settled: the uncertainty, in the author's opinion, being due to the fact that some writers have placed in the genus certain forms which differ widely from the typical species, and have then defined the characters of the

genus largely from these foreign forms. The author, in the light of the information now supplied, gives a fresh definition of the genus, which appears to represent a distinct family of perforate corals, in some features more nearly allied to the Favositidæ than to the Madreporidæ or Poritidæ.

(3) The third specimen was discovered by Miss Margery A. Reid in the Lower Carboniferous Beds of Halkin Mountain, Flintshire, and is named in honour of its discoverer. A description of it is given, and it is stated that, notwithstanding certain peculiarities, the individual pieces correspond so closely with those of the recent *Eunice* family that it may well be included in the genus *Eunicites*.

2. "The Eocene Deposits of Dorset." By Clement Reid, Esq., F.L.S., F.G.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

The new survey of the western end of the Hampshire Basin shows that the Reading Beds become fluviatile and gravelly in Dorset (as was already known), and contain, in addition to Chalk flints, many fragments of Greensand chert. The London Clay thins greatly and becomes more sandy, but is apparently still marine. The Bagshot Sands become coarser and more fluviatile, changing rapidly west of Moreton Station, till they consist mainly of coarse subangular gravel. These gravels, formerly referred to the Reading Series, are now shown to be continuous with the Bagshot Sands, which as they become coarser cut through the London Clay and Reading Beds to rest directly on the Chalk. The Bagshot gravels contain, besides Chalk flints and Greensand chert, fragments of Purbeck marble and numerous Palæozoic grits and other stones probably derived from the Permian breccias of Devon.

Thus there is evidence of disturbance and overlap in Cretaceous or early Eocene times, causing Reading Beds to rest on Upper Greensand. Later disturbances allowed the Bagshot river to cut into Greensand, Wealden, Purbeck, Permian breccia, Culm Measures, and granite. Folding of the strata seems to have taken place during at least four different periods in the district between Dorchester and Weymouth, which appears to have been a region of special weakness.

The Eocene gravels contain all the foreign rocks known to occur in the Plateau-gravels between Brighton and Dorchester. The fragments of Greensand chert, so abundant in the Plateau-gravels, have not been derived, as supposed, from the central axis of the Weald. They come, as already-formed pebbles, from the Eocene of Dorset, and originally from the Greensand of Devon.

3. "Discovery of Mammalian Remains in the Old River-gravels of the Derwent near Derby."—Part I. By H. H. Arnold-Bemrose, Esq., M.A., F.G.S.

A few mammalian bones were found in sinking a well at Allenton. On April 8th, 1895, the authors commenced further excavations, and were successful in finding the lower jaw, 26 vertebræ, the os

innominatum, left femur, tibia, fibula, calcaneum, cuboid, IV metatarsal, right fibula, calcaneum, cuboid, IV metatarsal, astragalus, left lunare and scaphoid, and portions of ribs of a *Hippopotamus*, also part of the breast-bone of an *Elephas*, and part of the tibia of a *Rhinoceros*. The *Hippopotamus*-bones were well preserved, and probably belonged to one animal. The body was most likely stranded in an old channel of the River Derwent, and quickly covered up with sand and clay, but not before the bones were somewhat disturbed. They were found in a dark-coloured sand above the river-gravel, at a depth of 9 feet 8 inches below the surface.

Mr. Clement Reid found some twenty or more species of plant-remains in the sand. These plants "indicate a moist meadow or swampy ground, and a temperate climate. The species are all widely distributed."

Part II. By R. M. Deeley, Esq., F.G.S.

The deposits in which the bones were found occupy a wide trench which occurs on the inside edge of a gravel-terrace stretching for several miles south of Derby, at a height of 15 or 20 feet above the modern alluvial plain. The gravels are of later age than the Great Chalky Boulder-clay, and were formed at a time when the rivers were removing from their pre-Glacial valleys the older Boulder-clays, with which they had been partially filled. Gravels of two ages are recognized: (*a*) recent gravels well stratified, undisturbed, and covered in many places by a thick layer of brick-earth; and (*b*) high-level gravels showing "trail" and contorted bedding. It is in these latter gravels that the trench containing the mammalian remains occurs. The deposits occupying this old waterway and the contorted high-level gravels are placed together in the same period; and the author gives reasons for supposing that they are both of Interglacial age, the contortions and surface-disturbances having been produced during a recent cold period, most probably by a lobe of ice which passed down the Trent Valley. Several peculiar physical features of the valleys, such as the flowing surface-outlines of the higher gravel-terraces, and the occurrence of lacustrine deposits in the low-level area occupied by Sinfin Moor, are instanced as supporting this view.

III.—May 13th. 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "An Account of a Head or Gateway driven into the Eastern Boundary-fault of the South Staffordshire Coal-field." By William Farnworth, Esq., F.G.S.

The author describes certain peculiarities observed during the driving of a head towards the fault separating the Coal-measures and Permian rocks, from a pit situated four miles east of Walsall, at the southern extremity of the Cannock Chase Coal-field.

2. "Dundry Hill: its Upper Portion, or the Beds marked as Inferior Oolite (G 5) in the Maps of the Geological Survey." By S. S. Buckman, Esq., F.G.S., and E. Wilson, Esq., F.G.S.

The authors give an account of previous geological work relating to Dundry Hill, especially that which refers to the correlation of its strata. Then they describe the different exposures on the Hill, together with the results of various excavations carried out by quarrymen under their superintendence for the purpose of the present communication. Besides demonstrating the sequence of the strata of Dundry Hill, the authors are able to show as special results—

The rapid easterly attenuation of the Freestone.

That there is a non-sequence in the Dundry deposits.

That the chief fossiliferous bed—the Ironshot Oolite—extends over a very small area.

That the absence of this bed is due to removal by almost contemporaneous denudation.

That in the easternmost portion of the Hill this bed and all the other beds of what is called Inferior Oolite have been removed by this denudation, so that only a thin cap of what would be called "upper beds of Inferior Oolite" rests on a thick clay-bed of the age of the Midford Sands.

That deposits contemporaneous with what are called "Upper Lias" and "Midford Sands" in other places are found in some thickness at Dundry Hill, attaining as much as 65 feet.

That the Lias Marlstone-rock is present at Dundry Hill and outcrops in many places on its flanks, but that this rock-bed is also wanting from many parts of the Hill.

That the Geological Survey have presumably mistaken this Marlstone-rock (which is an Ironshot stone) for the Ironshot Oolite—the chief fossiliferous bed of the Dundry Inferior Oolite, and formerly called *Humphriesianum*-zone — beds nearly 100 feet apart.

That, as a consequence, the map of the Geological Survey shows round the greater portion of the Hill the boundary-line of the base of the Inferior Oolite drawn as much below the Marlstone as would be correct if this rock had actually been the well-known Ironshot Oolite.

That, as a further consequence of this, the map of the Geological Survey shows coloured as Inferior Oolite, strata which would be mapped as Lower Lias, Middle Lias, Upper Lias, and Midford Sands in other localities, and that in places the limit for Inferior Oolite, according to the Survey, is as much as 600 yards beyond that of the authors.

The authors append a map of the strata of Dundry Hill, coloured on a palæontological basis, and they show how it may be compared with the map of the Survey and with a map by Saunders.

3. "On the Geographical Evolution of Jamaica." By J. W. Spencer, M.A., Ph.D., F.G.S.

The object of the paper is to set forth the physical and geological characteristics of Jamaica which bear upon the problem of its late high elevation and former connection with the continent, and to

trace across the neighbouring seas and islands to the mainland the evidences of the former linking of Jamaica to North and South America. The first part of the paper treats of the growth of the island, and the following events are described. After the formation of the mechanical sediments, limestones, and igneous rocks which constitute the basement of the "White Limestones," the latter group was accumulated in later Eocene and early Miocene times to a thickness of 2000 feet, and they indicate a subsidence of 3000 feet below sea-level. Their formation was followed by a Pliocene or Mio-Pliocene elevation in an epoch of long duration; the uplift was inferior to a later (post-Layton) one, but sufficient for the removal of Miocene limestone below sea-level. The period was one of general elevation, general dislocation of strata, and great erosion. The formation of the Layton marly beds with loams and gravels which succeeded this period is referred to the end of Pliocene times. In early Pleistocene times the "post-Layton" elevation occurred, causing an uplift of from 7000 to 11,000 feet above sea-level. The strata were not greatly deformed, but the epoch was one of enormous erosion. A subsidence somewhat resembling that of the Layton formation followed this erosion in late Pleistocene times, and caused the accumulation of the loams and gravels of the Liguanea formation. In modern times minor changes have occurred, causing the formation of terraces, of channels over banks, of coralline limestone, and of the modern coral terraces.

The second part of the paper treats of the continental connections of Jamaica. The author gives details of the submerged plateaux and drowned valleys which are analogous to those still existing above sea-level. They indicate that the former altitude of the West Indian plateau and some portions of the adjoining continent reached two and a half miles. But the floors of the Mexican Gulf and Honduras and Caribbean Sea formed low plains draining into the Pacific Ocean, for at the time the eastern region was high the Mexican area was generally low.

There was a generally high elevation of the Antillean region during the great Mio-Pliocene period, with probable continental connection; at the close of the Pliocene period a general subsidence flooded the coastal plains of the continent, and reduced the West Indies to fewer and much smaller islands than those which now exist. But the earlier portion of the Pleistocene period was that of the great continental elevation, when the lately-formed Pliocene topography was deeply dissected by rain and rivers, yet there were apparently several pauses of terrestrial movements at different altitudes, as indicated by the various base-levels of erosion. At this time Jamaica and other islands formed a mountainous tableland bordering the Mexican and Caribbean plains. Afterwards the later Pliocene continent was depressed so as to flood most of the coastal plains of the continent and reduce the islands to small proportions, and since then the minor oscillations have brought the old continent to the present conditions. Whilst the east was going down, the Mexican region and western lands were being raised to form high tablelands.

CORRESPONDENCE.

GEOLOGICAL SURVEY OF CAPE COLONY.

Sir,—In accordance with a resolution of the House of Assembly, carried last year, a Commission has been appointed in terms of the accompanying Notice, "for the purpose of organizing, controlling, and directing the work of Geological Exploration and Survey in this Colony."

The Commission has now appointed the undermentioned gentlemen to begin the work of surveying and mapping the country:—

Geologist: G. S. Corstorphine, B.Sc. (Edin.), Ph.D. (Munich).
Assistant Geologist: A. W. Rogers, B.A. (Cantab).
" " E. H. L. Schwarz, A.R.C.S.

As early as possible the Commission will publish and distribute a bibliography of South African Geology.

C. L. Lloyd,
Acting Secretary to Geological Commission.

Geological Department, South African Museum,
Cape Town, Cape of Good Hope.
February, 1896.

DISCOVERY OF INTERGLACIAL SHELL-BEDS IN AYRSHIRE.

Sir,—I beg to intimate that I have discovered Interglacial Shell-Beds at fourteen localities in Ayrshire, ranging from 55 to 740 feet above sea-level.

The Interglacial Beds attain a thickness at parts of over 100 feet, the usual arrangement being:

Upper Boulder-clay (*ground moraine*) with well-striated blocks up to 8 feet in diameter ...	76 feet
Sand Bed	a few ,,
Shelly Pebbly Clay	14 ,,
Sharp sand, gravel, and muddy sand ...	over 100 ,,
Lower Boulder-clay with large well-striated blocks	30 ,,

This is taking the beds at their thickest, but not seen in any one section.

The shells are all in *pebbly clay*, which I take to indicate that this bed was deposited *in deep water by surface-currents* carrying clay, and *shore-ice* carrying stones and gravel. I say shore-ice advisedly, as only a *few* of the stones in this bed reach a diameter of 20 inches. (Had this bed been deposited by *bottom currents*, the *clay* ought to have been swept away.) In some of the sections the shells are abundant, but mostly as *sharp-edged* fragments. Where there is a sand-bed between the shell-bed and the Upper Boulder-clay, the shells are in the best state of preservation, the sand-bed having acted as a *cushion* against the *trail* of the Upper Boulder-clay (*ground moraine*). Where there is no sand-bed in this position, the shells are more fragmentary and sometimes *scratched*.

I have traced the Interglacials, as gravel, sand, and muddy sand-beds, in the Bowbrone, Garpel, and Guelt valleys, to an altitude of 900 feet above sea-level. The shell-beds occur in the parishes of Loudoun, Sorn, Auchenleck, and Colmonell. The Interglacials range from Dalry to Colmonell, and inland to Muirkirk.

JOHN SMITH.

MONKREDDING, KILWINNING.
April 29th, 1896.

AMMONITES (ACANTHOCERAS) MAMMILLATUM IN THE ISLE OF WIGHT.

SIR,—In the GEOLOGICAL MAGAZINE for May, 1896, p. 199 (footnote 2), Mr. R. B. Newton calls attention to *Ammonites mammillatum* having been recorded from the Chloritic Marl in the Geological Survey Memoir on the Isle of Wight, second edition, p. 279, and suggests that there is a mistake. In this I think he is probably right. The table in the Memoir was drawn up in such a way as to show the authority for every fossil. *A. mammillatum* was inserted on the authority of Captain Ibbetson ("Note on the Geology and Chemical Composition of the various Strata in the Isle of Wight," 1849, p. 22), who quotes *A. monile* from the Chloritic Marl. *A. monile*, Sow., according to D'Orbigny (Pal. Franç. Terr. Crét. 1840–1, p. 249), Bronn (Index Pal. 1848, p. 51), and Morris (Cat. Brit. Foss. 1854, p. 297), is *A. mammillatum*, Schloth. The mistake probably lay in the determination of Ibbetson's specimen as *A. monile*.

A. STRAHAN.

12, MARLOES ROAD, KENSINGTON, W.

ICE-WORK.

SIR,—The author of the excellent summary of my book on Ice-Work (see GEOL. MAG. for last month, pp. 228–231) seems to have misunderstood me in one respect. In regard to the parallel roads of Glenroy, he states—"the objections to a marine origin for these 'roads' are regarded as insuperable." I think that a comparison of pages 94–107 with pages 163–198, will show that this is not my opinion. Indeed, I have more than once maintained the contrary. I venture on this correction lest I should be supposed to have changed my mind.

23, DENNING ROAD, HAMPSTEAD, N.W. T. G. BONNEY.
May 16th, 1896.

MISCELLANEOUS.

GUIDE TO THE MUSEUM OF PRACTICAL GEOLOGY.—The "Descriptive Guide" to this Museum, of which a fourth edition was published in 1877, has long been out of print, and a new edition has been